TO STUDY THE UNION RATES AND COMPLICATIONS ACCOCIATED WITH SURGICALLY MANAGED FRACTURE CALCANEUM

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Submitted By

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DECLARATION BY THE CANDIDATE

I hereby declare that the thesis entitled "**TO STUDY THE UNION RATES AND COMPLICATIONS ASSOCIATED WITH SURGICALLY MANAGED FRACTURE CALCANEUM**" submitted towards partial fulfillment of the requirements for the award of **MS in Orthopaedics** degree to BFUHS is a compilation of original work carried out by me under the supervision of **Dr. Rajnish Garg**, Professor & Head, Department of Orthopaedics and **Dr. Shekhar Singal,** Associate Professor, Department of Orthopaedics. No part of this thesis has formed the basis for the award of any degree previously.

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Dedicated

to

my Family,

friends

&

Teachers

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Dr. Ramandeep

ABBREVIATIONS

AOFAS	AMERICAN ORTHOPAEDIC FOOT AND ANKLE SOCIETY
CNS	CREIGHTON- NEBRASKA SCORING SYSTEM
CT	COMPUTED TOMOGRAPHY
DWI	DEEP WOUND INFECTION
DM –II	DIABETES MELLITUS
HTN	HYPERTENSION
I/A	INTRA ARTICULAR
ORIF	OPEN REDUCTION AND INTERNAL FIXATION
PRE -OP	PRE OPERATIVE
POST-OP	POST OPERATIVE
RSA	ROAD SIDE ACCIDENT
ROM	RANGE OF MOTION
SWI	SUPERFICIAL WOUND INFECTION

ABSTRACT

INTRODUCTION:- Calcaneum is the most commonly fractured tarsal bone. Calcaneum fracture accounts for 2% of all and 60 % of all tarsal bone fracture. Majority of calcaneum fracture occurs in male between 21 -45 yrs of age and this has major socioeconomic impact. Treatment of calcaneum fractures remains a topic of debate. A wide range of treatment options varying from non operative to operative methods are available. The purpose of this study is to analyse the union rates and complications of surgically managed fracture calcaneum. The details of history, clinical examination and radiological grading were entered into a performa.

Material and methods: 18 Patients of fracture calcaneum who were evaluated at our centre between 1st january 2017 to march 2021 were included in this retrospective and prospective study. Sander's classification was used to classify the fractures. Follow up was done at 4 weeks, then at 3 month, and at 6th months. AOFAS scoring system was used to assess the functional outcome of patients.

Results:- The mean age of the patients in our study was 36.8 years. Male to female ratio was 8:1. Most common mode of injury was fall from height. Association of calcaneum fracture with spine injury was seen in 33.3 % of patients. Out of total 18 cases, 10 cases were Sander's TYPE III, 6 were Sander's Type II and 2 were Sander's Type IV. Average fracture union time in our study was 12 weeks. in our study out of total 18 patients, 2 patients had excellent result , 8 patients had good result, 6 patients had fair results and 2 patients had poor results according to AOFAS scoring system. Various complications like superficial infection, deep infection, heel exostosis was present in one case each while impingement of metal work was present in 2 cases and varus deformity was present in 3 patients.

Conclusion:- From our study it can be concluded that open reduction and internal fixation of fracture calcaneum with locking compression plate has better results in term of union rates and functional outcome.

Key words:- Calcaneum, AOFAS, sander's classification.

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INTRODUCTION

Calcaneum is the largest tarsal bone and also the most commonly fractured tarsal bone. Calcaneum is the major weight bearing osseous structure of foot. It is one of the components of tri –tarsal articulation and it also has functional tasks with regards to normal ambulation [1] .As the calcaneum is important for normal mechanics of locomotion so it is easy to justify why calcaneum fracture is associated with considerable morbidity . Calcaneum fracture accounts for 2 % of all and 60 % of all tarsal bone fracture . Spine fractures are associated with 10 % of calcaneum fracture while other extremity injuries are associated with 26% of calcaneum fracture [2] .Since the humans have assumed the erect position and stared to defy gravity, the fracture of the calcaneum bone has been common and often disabling injury .For the orthopaedic surgeon , calcaneal fractures are among the most therapeutic challenging fractures. Majority of calcaneum fracture occurs in male between 21 -45 yrs of age and this has major socioeconomic impact [3]. Patient with fracture calcaneum remains away from work and from recreational activity for a longer duration of time. Ordinally speaking the man who breaks his heel bone is done as far his industrial future is concerned .[4]

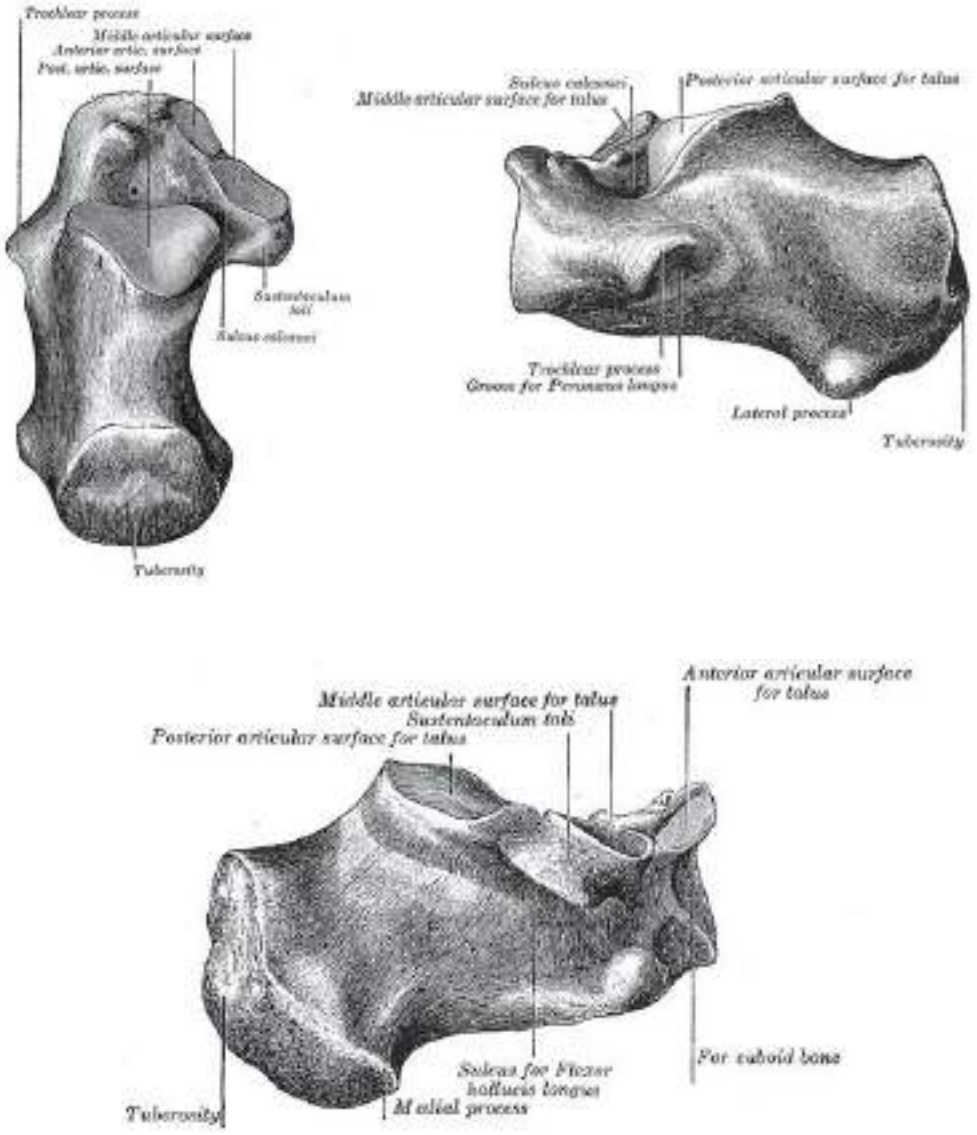
Calcaneum fracture can be divided into two types based on the extension of fracture into the subtalar joint. Intra articular (sparing the subtalar joint) and extra articular (involing the subtalar joint). Intraarticular type being the most common and associated with poor function outcome [5,6,7] Calcaneum fracture usually occurs from axial loading with varring degree of shear force, such as fall or motor vehicle accident.

Treatment of calcaneum fractures remians a topic of debate. Historically most of the calcaneum fracture were treated non operatively because open reduction and internal fixation not only associated with higher complication rates but also the outcome of surgical management did not result in significant improvement due to inadequate reduction techniques and improper imaging modalities. However , over the last 25 years, with

the better understanding of fracture pattern , improved surgical and fixation techniques , advances in anaesthesia , prophylactic antibiotics , advances in imaging modalities like CT scan and fluoroscopy all these allowed the surgoens to improve the outcome of fracture calcaneum after surgical management [8]

Anatomy of calcaneum.

The largest bone among the 7 tarsal bones is calcaneum and it is the first tarsal bone to ossify [9]. Calcaneum transmits the body weight to the ground and it also provide the strong lever for calf muscles [10].Calcaneus has 4 articular surfaces. The calcaneum has 3 articular facets for articulation with talus on the anterior portion of superior surface. the posterior portion of superior surface terminates as the calcaneal tuberosity. Out of the 3 articular facets the posterior one is the largest one and is convex in longitudinal axis. on axial view (harris-beath) only the central portion of facet is visible therefore For the evaluation of the entire facet broden's views are taken.[11] The part which separates the middle facet and posterior facet is sulcus calcaneus which is the floor of tarsal canal .The tarsal canal empties laterally and distally into the sinus tarsi , and sinus tarsi has 5 ligaments :- 3 portion of extensor retinaculum , the oblique talocalcaneal ligament and ligament of tarsal canal [12]. The middle facet which is conave and oval, is situated on the upper surface of sustentaculum tali. The anterior facet lies in anterolateral portion of middle facet . The anterior facet is supported with the help of beak of the calcaneum. Anatomy of the anterior and middle facet is variable. The 3 variations described by viladot and colleagues are :- combined facet , 2 separate facets , congruent facet in bean shape[13]



PICTURE 1- ANATOMY OF CALCANEUM [14]

Acetabulum paedis , which is formed by the anterior facet , middle facet , the plantar calcaeonavicular ligament and posterior articular surface of navicular bone , contains the head of talus [15]

Calcaneum is mainly composed of cancellous bone contained by the thin cortical shell . Laterally, the lateral process of the talus is supported by the anterior process of calcaneum . Peroneal tubercle which is present posterior and lateral to anterior process is the site where insertion of peroneal retinaculum occurs .Tendons of peroneus brevis (superior) and

peroneus longus (inferior) separated by the peroneal trochlear that lies just posterior to peroneal tubercle.

Force of the Weight of body is transmitted through the 2 tuberosities Which are located poteroinferiorly [16]. Out of the 2 tuberosites the medial one is the largest. Sustentaculum tali is dominated over the medial surface of calcaneum and there is grove for the flexor halluces longus tendon on the inferior surface of sustentaculum tali . The superomedial calcaneonavicular ligament and the talocalcaneal component of deltoid ligament, both these ligaments are attached to the sustentaculum tali .

When viewed laterally ,the calcaneus trabeculae forms the neutral triangle . Apex of the triangle corresponds to the thalamic portion of the calcaneum [17], it is a point where compression trabeculae converge to support the anterior and posterior facet. While traction tarbeculae which radiate from the inferior cortex, from the base of the triangle.

According to harty , the blood vessels reaches the medullary cavity of the calcaneus is through this neutral angle and therefore this triangle is commonly associated with early manifestation of blood borne infections [18]

On lateral x ray , crucial angle of gissane can be calculated . Normally this angle ranges from 120 to 145 degree. This angle Is formed by drawing 2 lines , first from anterior process to sulcus calcaneum and a second line along the posterior facet . The lateral process of the talus rest with in the angle of gissane and it is this angle from where the primary fracture line passes in calcaneum fracture . [19,20,21,22] another angle that can be calculated on lateral x-ray is bohler's angle which is formed by 2 lines, first line extends from the highest point on the calcaneal tuberosity to highest point on posterior articular surface and a second line is from highest point on the anterior process to the highest point on the posterior articular surface. Normally this angle ranges from 25 to 40 degrees. Degree of compression and deformity in calcaneum fracture can be assessed with the help of decrease in bohler's angle [20,23,24]

Mechanism of injury

Fall from height is the most often cause of calcaneum fracture which is responsible for 80-90% of cases. Whenever a patient fall from height, the compressive forces not only fracture the calcaneum but other proximal injuries may also be present

According to cave, dorsal and lumbar spine compression fractures are present in 10 % of calcaneum fractures and lower limb injuries are present in about 25 % calcaneum fracture[2]

Extraarticular fractures (anterior process, sustentaculum) are usually caused by twisting forces

Intraarticular fractures

Axial compression forces are frequently associated with the I/A fracture of the calcaenum. [21,24, 25,26] fall from the height or motor vehicle accident are the most common causes because in these most of the force is dissipated through the heel only.

At the time of the accident the factors that determine the fracture pattern are quality of the bone , position of the foot and the amount of force .[27]

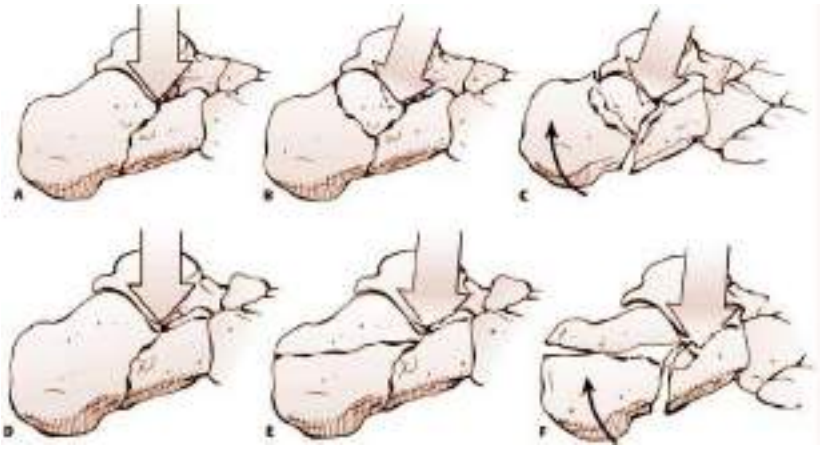
The calcaneum is placed eccentrically and in slight valgus position under the talus. Whenever the talus undergoes in compression the lateral process pushes the subtalar joint to go into eversion and act as wedge at the critical angle.[21,24,27] which results in primary fracture line (by essex lopresti). Posterolateral (tuberosity and body) and superomedial (sustentaculum) are the fragments that are produced by this primary fracture line .

As the compression force continues over talus , the secondary fracture line formed starting from posterior aspect of subtalar joint Essex lopresti[21] recommended that with this secondary fracture line two types of fracture fragments can occur according to the direction in which the force dissipated.

If the secondary fracture line is posterior and superior to posterior facet then joint depression type fragment produced. (tuberosity is not involved in

joint depression type) in this the superolateral free fragment depress down into the cancellous deficient neutral triangle.

If secondary fracture line extend into the tuberosity then tongue type fragment produced. Anterior portion of tongue type fracture fragment depresses while the posterior portion elevates due to which there is reversed bohler's angle.



PICTURE 2- A,B,C REPRESENTS THE MECHANISM OF INJURY OF JOINT DEPRESSION TYPE OF ESSEX LOPRESTI CLASSIFICATION AND D, E, F REPRESENTS THE MECHANISM OF INJURY OF TONGUE TYPE OF ESSEX LOPRESTI CLASSIFICATION [28]

Radiology

whenever a patient with suspected calcaneal injury is evaluated initially ,radiological examination with standard roentgenogram should be done .Because of the fact that majority of the calcaneum fractures occurs due to fall from height and spine injuries are also common in fall from height patients. Therefore radiological examination of spine is essential as association of calcaneum fracture with spine injury is common . Radiological examination of calcaneum should include at least 3 views:- lateral radiograph of hindfoot, anteroposterior radiograph of foot , harris axial view of heel [8]

For the evaluation of height of calcaneum , bohler's angle and angle of gissane , lateral radiograph is required . In cases of calcaneum fracture the bohler's angle [24]usually depresses and crucial angle of gissane is widened[29]. lateral radiograph also useful in evaluation whether the fracture is joint depression type or tongue type .

Antero posterior radiograph is used for evaluation of possible extension of fracture line into the calcaneocuboid joint, any subluxation of talo-navicular joint and any midfoot fracture.

Harris axial radiograph is used for evaluation of the lateral wall comminution, width of hind foot and position of the heel. In acute cases, this view is difficult to get because of the pain.

To evaluate the entire articular surface of posterior facet from anterior to posterior Broden 's projection I [30] is used in this view the patient is made to lie supine with the radiograph cassette under the leg and ankle with foot in neutral flexion and leg is rotated internally to approximately about 30 to 40 degree . After that 4 radiographs are taken with tube angled at 40, 30, 20, 10 degree with beam of x rays centred over the lateral malleolus.[31,32,8]

With the advancements in imaging modalities (CT Scan), understanding of the calcaneum fracture has significantly increased[32,33,34,35]. In CT scan both coronal and transverse images are obtained, coronal sections are perpendicular to posterior facet whereas the transverse sections are parallel to the foot .coronal sections mainly useful to see the number and location of articular fragments which is also the basis of the SANDER'S classification scheme. In transverse section, the lateral wall blowouts and also the antero-inferior posterior articular facet can be seen.

CLASSIFICATION OF CALCANEUM FRACTURE

Throughout the last century, many classification systems has been proposed and most of them were based on the plain standard radiographs which are difficult to interpret consistently.

Classification system for calcaneum fracture was first described by the Bohler. There were 8 fracture types in his classification system and out of which 4 were intra articular and other 4 were extra articular types[36]

In 1952 Essex lopresti [21] developed a simple and extensively used classification system on the basis of mechanism of injury .He described 2 types (tongue type and joint depression type) based on the location of the secondary fracture line . In tongue type , the secondary fracture line extends longitudinally into the tuberosity whereas , the secondary fracture line in joint depression type is posterior and superior to posterior facet not involving the tuberosity .In this classification , the fracture type only describes the treatment not the prognosis .

In 1970's , soeur and remy [17] described a classification system, based on the number of articular fragments . Standard plain radiogarphs (A-P, Lateral, harris axial view) were used for evaluation of the posterior facet. The fracture were classified into 3 degrees :-

In first degree – fractures were non displaced

In second degree- secondary fracture lines were present , which resulted in 3 fragments .

In third degree – severely comminuted fracture

In 1993, Sander's [33] described a classification based on the number of fracture fragments that are identified on the coronal images of CT scan. Coronal image of CT that is used, is the one which display the widest undersurface of the posterior facet of the talus .

Type I :- All undisplaced intra articular fractures(less than 2mm displacement regardless of no. of fracture lines)

Type II :- Type two is further divided into II a , II b , II c

II a- involves primary fracture line that passes through the lateral aspect of the posterior facet

II b- involves primary fracture line that passes through the central aspect of posterior facet

II c - - involves primary fracture line that passes through the medial aspect of posterior facet

Type III :- Type III is further divided into IIIab , III ac, III bc

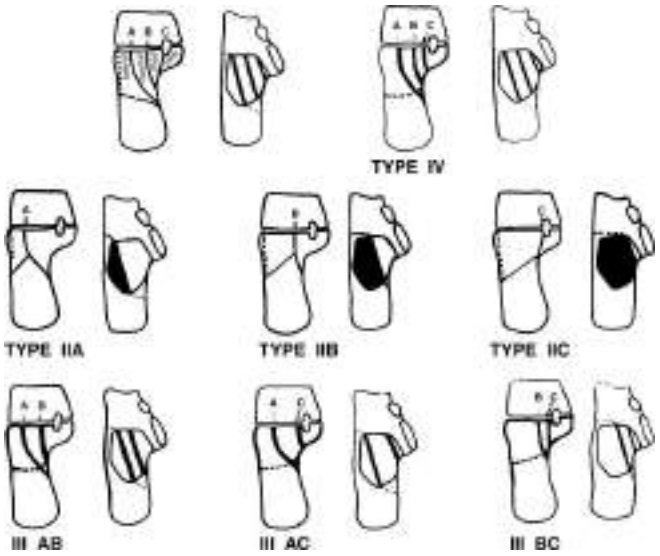
III ab – involves the two primary fracture lines. one passes through the lateral aspect of the posterior facet and the second through the central aspect of the posterior facet. This subtype usually present with central depressed fragment

III ac - involves the two primary fracture lines. one passes through the lateral aspect of the posterior facet and the second through the medial aspect of the posterior facet. This subtype usually present with central depressed fragment

III bc - involves the two primary fracture lines. one passes through the central aspect of the posterior facet and the second through the medial aspect of the posterior facet. This subtype usually present with central depressed fragment

three part fracture usually with a central depressed fragment .

Type IV :- involves three or more intra articular primary fracture lines with displacement of more than 2 mm . Type IV fracture are severely comminuted fracrures.



PICTURE 3 SANDER'S CLASSIFICATION OF INTRA ARTICULAR CALCANEUM FRACTURE.[33]

TREATMENT

The treatment of calcaneum fracture remains controversial ,even in the recent times some authors recommend conservative management while other recommend operative management for calcaneum fracture. However with the better understanding of fracture pattern, improvement in surgical and fixation techniques, advances in imaging modalities many surgeons now prefer operative management over conservative management . In general conservative treatment is recommended in cases in which the fracture pattern is simple, non-displaced and extra articular. Conservative treatment is also recommended in patients who are not fit for surgical management like elderly patients , patients with uncontrolled DM-II or peripheral vascular disease. Surgical intervention should be done in cases in which the fracture pattern is complex, I/A fracture and displaced fractures. While performing surgical management stress should be given to restore the anatomy of the calcnauem rather than just focusing on the reduction of posterior articular facet or restoring the length of the calcaneum.

NON OPERATIVE MANAGEMENT INCLUDES :-

1. No attempt of reduction , accept position :-
   REST, ICE, ELEVATION, NSAIDS

Early range of motion started. Once swelling subsides, paitent can be fitted with removable boot or splint to be given in 90 degree to prevent equinus contracture,[31]

Weather to bear weight on affected limb or not is controversial. Zwipp et al [32] recommended upto 20 kg weight on affected limb for 6- 10 weeks whereas sanders et al[31] , suggested non weight bearing for 12 weeks

2. Non operative management after closed reduction

Omoto and Nakamura[37] recommended technique of longitudinal traction with repetitive squeezing of heel after which short leg walking cast is given with heel in 45 degree of equinus. This technique mainly focus on ligamentotaxis.

MINIMALLY INVASIVE TECHNIQUE :-

Benefits include:- less soft tissue trauma and cost effective

In 1934 Westhues[36] introduced the concept of indirect closed reduction and percutaneous fixation .This concept was popularised by gissane in united states [21]

Essex lopresti[21] used this technique to reduce the tongue type fracture but he mentioned that joint depressed fragments cannot be reduced by this technique because control of depressed fragment was not obtained using this technique

Rammelt et al [38] used this technique of closed reduction and percutaneous fixation to fix sanders type II c fractures (without arthroscope) while he fixed sanders type IIa and type II b fractures with same technique but with the help of arthroscope to view reduction.

Zwipp et al.[39] conducted closed reduction and percutaneous fixation in 21 patients with sanders type II a and type b. After one year, 15 pts were available for follow up and it was found that the mean AOFAS score in those 15 pts was 94.1. No wound infection were seen and mean bohler's angle improves from 13.1 to 25.8. Result concluded from this study was that sanders type II fracture can undergo percutaneous closed reduction but type IIa and type II b require arthroscopic assistance.

SURGICAL MANAGEMENT

If the surgeon has decided to perform the surgery, the timing of the surgery is very crucial

In case of closed fracture of calcaneum surgery is not indicated until swelling subsides. Sander suggested that surgery should be done only after positive wrinkle test [31]

Various approaches for fracture calcaneum are:-

- Medial approach
- Sustentacular
- Sinus tarsi
- Extended lateral approach

- Combined approach

As the surgical intervention gain popularity again in 1970s, investigators mainly concentrated on restoration of shape of calcaneum.

Mcreynolds and burdeaux[34,40] by using medial approach get reduction of tuberosity to superomedial fragment but due to no direct visualization of posterior facet, reduction of joint surface was not adequate

Extended lateral approach

Advantages – proper view of posterior facet and lateral calcaneal wall

In 1940's palmer [41] popularised the original lateral or kocher approach But wound infection rates were high with this apporach

Letournel[42] modified palmer's approach by making the skin incision more posteriorly and inferiorly and lifting full thickness flap so that peroneal tendon and sural nerve are not disturbed .

No touch technique was also introduced in which k wires were inserted into the lateral malleolus , talus neck and k wires were bend to function as retractors which prevent the blood supply of flap, which otherwise can be compromised by over retraction.

PRIMARY SUBTALAR ARTHRITIS

Anatomic reduction of articular surface of posterior facet, in Sander's type 4, may not be obtained. In a study conducted by sander's et al.[33] total of 120 calcaneum fracture were taken and out of which 11 were type 4 fractures , none of the patient had anatomic reduction and only 3 calcaneum had near normal reduction . out of 11 calcaneum fracture only one had good outcome. Therefore some of the investors, because of the inability to reduce the joint anatomically, they recommended primary joint arthrosis. The calcaneal height, length of the calcaneum and reduction of the joint should be restored as best as possible ,and after that remaining of the cartilage removed from both side of posterior facet and bone graft can be used to assist primary subtalar arthrosis. In addition to placement of lateral plate for the body of calcaneum lag screws are also placed from calcaneum tuberosity to talus.

COMPLICATIONS

Surgical management of closed calcaneum fractures has been widely accepted in 1990's. The basic aim of the ORIF is to obtain the realignment of posterior facet and height of hindfoot. ORIF has various benefits over the previous techniques, like Essex lopresti tech. ORIF restores the normal morphological structure and foot biomechanics. It also prevents the pain and stiffness at subtalar joint mainly by early range of motion of foot.

Howerver, ORIF of calcaneum is also associated with various post operative complications like infection, skin flap necrosis, neurovascular injury, mal reduction, implant problems, post traumatic arthritis and non-union. All these complications can result in low functional score on American orthopaedic foot and ankle society (AOFAS) [43] which indicated considerable disability. All these complications not only results in various symptoms but also place economic burden on the patient[44]

INFECTION

The outer layer of soft tissue of the calcaneum is most susceptible to infection because of the reason that the lateral calcaneum receives its blood supply only from the lateral calcaneum artery and thus after injury it is likely to develop hypoxia [45] Lateral calcaneum also has thinner soft tissue structure as compared to other bones, that also contributes to postoperative infection [43] The timing of the surgery is also considered to be an important factor in infection. Buckel et al. believed that the management of the soft tissue to be critical and did not suggested early surgery [46] if the superficial infection occurs , then these were suggested to be treated by debridement , changing the dressings daily , local wound care and by giving intravenous antibiotics according to culture sensitivity [47] if the infection is diffuse then all the implant should be removed, debridement(removal of dead and necrotic bone and tissue) should be done and antibiotic (3rd gen. cephalosporins) should be given for 6 weeks [48] if the most of the calcaneum could be retained after doing the

debridement then arthrosis of hindfoot could be considered but in cases where infection diffused to most of the parts of foot then amputation is the only option[48,45]

SKIN FLAP NECROSIS

Skin flap necrosis usually occurs because of the improper incision and exposure or due to the lengthy time taken for distraction.[49] the most commonly observed site of the necrosis is the corner of the L shaped lateral incision probably due to the areas supplied by the peroneal artery [43] most of the times skin flap necrosis can be prevented by the curved incision and exposure should go directly by sharp dissection from skin flap to periostem without distraction And sutures applied for closure of incision should be without tension [50]. Even if the skin flap necrosis occurs, necrotic tissue debridement and dressing with the povidone iodine gauge can often results in good outcome [51]. However skin slap transplant might be considered if the necrotic area is more then 3.5 cm wide

NERVE INJURY

Acute nerve injury commonly occurs iatrogenically. In lateral approach, structure that is at most risk for injury is the sural nerve whereas in medial approach damage to the calcaneal branch of posterior tibial nerve can occur [52]. The injury to both medial and lateral planter nerves can occur in lateral approach during drilling or inserting the screws. To avoid the injury ,through anatomical knowledge and surgical technique are essential .

HEEL PAIN

Three anatomic areas where heel pain can occurs are:- lateral aspect of heel , medial aspect and over the point of heel

Pain over lateral aspect of heel from Subtalar arthritis is one of the most common cause of disability after fracture calcaneum [53]. Pain usually increases on walking and relieved by injecting the xylocaine into joint [54] Reffered pain on inversion or eversion of foot to area of sinus tarsi suggestive of subtalar arthritis and if the pain relieved on injecting local anaesthetic then fusion of subtalar joint may be indicated [55]

Whenever there is comminuted fracture of the lateral cortex of the calcaneum some of the fragments of the fracture that are displaced in the medial lateral plane comes under the lateral malleolus and if the fragments unite in this position , they produce permanent bony prominence over the lower end of fibula [56] which can result in the entrapment of peroneal tendon into the callus or rubbing of tendon against the fibula or abutment of tip of fibula [57] physical findings like point tenderness over the peroneal tendons, limited movement at subtalar joint and antalgic gait are suggestive of peroneal tenosynovitis. peroneal tenosynovitis symptoms can be treated conservatively by injecting steroids but in case symptoms persist bony prominence excision may be helpful [58] Calcaneocuboid joint arthritis is the 3rd most common case of pain after calcaneum fracture pain can result from the malposition of joint due to malunion of calcaneum or due to the involvement of calcaneocuboid joint itself during intial fracture of calcaneum.

PAIN OVER POINT OF HEEL

Plantar heel spur is the cause of the chronic heel pain after calcaneum fracture. bony prominence formed Due to the plantar displacement of fracture fragments after Intial trauma and there union in same position lead localized tender areas over the planter surface of calcaneum [59]. Treatment mainly include use of heel pads to relieve pressure. In cases that do not respond to conservative treatment excision of the calcaneum spur can be done.[60]

HEEL PAD PAIN

Pain over planter surface of foot after weight bearing can result due to the rupture of fibrous septa and fat filled compartments in soft tissue. This rupture of fibrous tissue and fat filled compartment leads to loss of hydraulic buffer that protect the heel. Heel cushion or orthotic shoe is recommended if heel loss is present [60]

ANKLE JOINT AND FLEXOR TENOSYNOVITIS

Pain beneath the medial malleolus is the second most common site of pain following the calcaneum fracture and it is basically because of the ankle joint damage and damage to flexor tendons that are present beneath the medial malleolus and it is not due to the subtalar arthritis [59]

MALUNION

Malunion mainly occurs in those cases that are managed conservatively but it can in occur in cases that are managed surgically in which there is inadequate or improper reduction.

Malunion leads to various problems like widened heel syndrome , pain and instability secondary to tendon impingement , post traumatic arthritis of the subtalar or calcaneocuboid joint , altered gait secondary to hind foot malalignment and nerve impingement [61,31]

ARTHRITIS

Subtalar incongruity or penetration of implants into the subtalar joint result in late arthritis which is associated with poor outcome. With articular surface depression of as little as 2 mm there is significant unloading of the posterior facet , supporting the concept of articular surface reduction as aim of treatment in operative management of calcaneum fracture[62]. Even in cases where fractures are anatomically reduced, arthritis can occur due to the cartilage damage caused by the initial trauma. Therefore it is the severity of initial trauma which decides the final outcome and not the quality of the articular surface reduction [63]

AIMS AND OBJECTIVES

To analyse the union rates and complications associated with fracture calcaneum managed surgically (ORIF).

REVIEW OF LITERATURE

Calcaneum is the most controversial bone to break. [64] in the last century, there has been controversy regarding the management of fracture calcaneum whether closed reduction has benefits over open reduction or vice versa.

Hippocrates has described the appearance of the heel of a patient who had fallen from height, however he did not probably recognize a “calcaneum fracture “, making this case perhaps the first documented missed calcaneum fracture in history. [65]

In 1720, 1st documentation of treatment of calcaneum fracture was given by petit and desault [66] they suggested rest and limb elevation for calcaneum fracture, which till end of 19th century, remains the principle treatment.

In 1880, paszkowski was the first to described treatment of fracture calcaneum by immobilization in a cast [66]. Although with the advancement in technology and better understanding of calcaneum fracture, many treatment methods are evolved but till recently immobilization in cast is still the viable method of treatment

In 1902, morestin was the one who first described open reduction and internal fixation of fracture calcaneum. He used direct lateral approach to lift the depressed fragment of posterior fragments [66,67]

In 1908, cotton and wilson [68] were the first to realise that reduction of lateral wall of calcaneum important. They recommended closed treatment with the help of sandbag placed medially, felt pad placed laterally and hammer to reduce the lateral wall of calcaneum. They also suggested that open reduction was contraindicated for calcaneum fracture.

In 1931, Bohler focussed on restoring the tuberosity joint angle [24] He also suggested open reduction but the technical problems associated with operative management was the reason for predominance of non-operative management

In 1935, Conn [25] was not satisfied with the results of treatment methods of calcaneum fracture i.e. closed reduction technique and he commented on " serious disabling injuries in which the end results continue to be incredibly bad ".conn noted the traumatic flatfoot deformity which comprises of "pronated heels, planus arches and valgus forefoot with pain " therefore he suggested to take out the healed , malunited fracture and perform triple arthrodesis to restore the position and alignment, which had excellent results .In 1943 , Galie suggested subtalar arthrosis for healed fracture as definitive management [69]

Palmer [41] was not satisfied with the closed and delayed management of calcaneum fracture. In 1948 he suggested performing an open reduction of joint surface augmented with bone graft through the use of standard kocher approach for acute calcaneal fractures. after 4-8 months all the patients joined to their previous work. Similar findings were described by Essex- lopresti. Essex- lopresti classified intraartcular calcaneum fracture into 2 types :- Tongue type and Joint depression type

In 1952, Essex- lopresti [21] studied 133 consecutive cases of calcaneum fracture, there mechanism of injury, fracture lines (primary and secondary) and demonstrated the technique of reduction of fracture calcaneum using axial pin and maintaining the reduction with the help of plaster cast. He concluded that closed reduction for tongue type and open reduction for joint type results in good outcome.

Dick [70] and harris [71] began to use the Gallie's technique of subtalar arthrosis for healed fracture as a treatment of acute calcaneum fractures and they had excellent results

Lindsay and dewar [72] in 1958 and lance et al [73] in 1963 reported better results after early mobilization of patients with fracture calcaneum who were managed conservatively After this article, once again surgical management of fracture calcaneum fell into disfavour. Many surgeons continued non operative management for calcaneum fracture during 1960s and 1970s [2,74]

In 1971 Poupa and Pribyl [75] reviewed 34 cases of Essex loprsti tongue type fracture of calcaneum and results were evaluated using creighton-nebraska scoring system. It was concluded that Essex lopresti spike fixation technique for management of tongue type fracture is useful

In 1973 king [76] reviewed the outcome of 75 consecutive fractures of calcaneum involing the posterior facet managed by Essex-lopresti technique it was found that tongue type fracture had better results whereas joint drepession type had less satisfactory results. Therefore he concluded that essex lopresti fixation technique is good for tongue type fracture of calcaneum .

In 1992, Richard E buckley and Robert N. [77] conducted a study to compare the open versus closed reduction of intraarticular calcaneal fracture. In the study 17 displaced intra articular calcaneal fracture were managed operatively and were compared with 17 non operatively managed displaced fracture calcaneum among workers' compensation board patients. Both the groups were matched in terms of fracture pattern, age, year of injury and occupation. follow up was done for 6.3 yrs in operative and 5.4 years in non-operative patients. No significant difference was found between the 2 groups in heel pain, subtalar motion and return to work. In those patients that were managed operatively the overall result was better when the subtalar joint was reduced anatomically

In 1993, K.S. Leung et al [78] conducted a study in which operative management of displaced intraarticular fractures of calcaneum compared with calcaneum fracture treated non operatively. In the study 44 patients were assessed after a mean follow up of 2.92 years and compared with 19 patients that were managed conservatively. Scoring system of Crosby and Fitzgibbons (1990) were used for clinical scoring and lateral, axial and internal oblique views were used for radiological measurement. In the study it was found that better results were obtained in operated patients in terms of pain, activity, range of motion, return to work and swelling of hind foot

In 1993, D. A. O'Farrell et al [79] a prospective study of 24 patients with I/A fracture calcaneum was done to compare operative management with non-operative management of calcaneum fracture. out of 24 patients 12 were managed with open reduction and internal fixation following which early mobilization was started and 12 were managed non operatively. the patients were assessed using 8 parameters after 15 months. out of 12 patients those managed conservatively, 8 returned to work. Walking distance was also significantly longer and only one patient required change in shoe size. out of 12 patients managed conservatively, 3 returned to work and 8 required change in shoe size and average walking distance was only 1 km without pain. Mean subtalar joint range of motion was 24 degree in operated group and only 12 degree in non-operated group. they recommended displaced I/A fracture calcaneum to be managed operatively using lateral approach in patients under 40 yrs of age.

In 2005, A. Koski et al [80] conducted a retrospective study to analyse the post-operative complications after internal fixation of closed fracture calcaneum and the risk factors leading to these complications. 126 patients were selected with 148 fracture calcaneum managed operatively. Wound infection was seen in 23 cases, wound edge necrosis was seen in seen in 12 patients. soft tissue complication require operative management was seen in 20 cases. It was concluded that longer delay in surgery and longer operative time were the positive risk factors for wound complications

In 2006, William C. McGarvey et al [81] conducted a study to evaluate the use of indirect reduction with ilizarov external fixator as alternative in surgical management of calcaneum fracture. 31 patients were selected with 33 fracture calcaneum and they were treated with small circular wire external fixator. Patients were evaluated by physical examination and AOFAS hind foot score. Follow up ranges from 6 months to 4 years. The average AOFAS score was 66 in 18 patients available for examination and

average score increased to 74 in patients with more than 10 month follow up whereas the score increases to 77 in patient with isolated fracture calcaneum Complication were seen in 11 patients. out of 11, 9 had superficial pin tract infection, one had superficial skin necrosis and one deep infection seen in diabetic smoker with severe haemorrhagic fracture blister. All superficial infections responded well to oral antibiotics and local pin care. It was concluded from this study that indirect reduction and external fixation is a viable surgical alternative for fracture calcaneum and had advantages of shorter time to surgery, immediate weight bearing, no hardware and minimal invasive procedure. Favourable results were seen in open fractures.

In 2013, A.K. singh et al [(82)] conducted a retrospective study to determine the need for bone grafting in surgical treatment of intra articular displaced fracture calcaneum. 390 patients of displaced fracture calcaneum who were treated with plate osteosynthesis with or without iliac bone graft were reviewed. Out of 390 patients, 202 patients (group A) were managed with osteosynthesis with bone graft whereas remaining 188 (group B) patients were treated with osteosynthesis without bone grafting. It was concluded that full weight bearing time in group A was significantly lower as compared to the group B . The loss of bohler's angle after 2 year of follow up was significantly lower in group A as compared to group B. However, no significant difference was seen between the 2 groups in terms of functional outcome and complication rates.

In 2013, Liang Ding et al. [(83)] conducted a study to evaluate the risk factors for post operative wound complication in closed fracture calcaneum undergoing operative management. Total of 490 fractures that were managed surgically were evaluated. it was seen that smoking history, DM, sander's type, number of fellow present during surgery, duration of surgery, estimated blood loss and 10 or more than 10 people present during entire surgery were related to increase risk for post operative wound complication in surgically managed closed fracture calcaneum. out

of these smoking history, diabetes mellitus and sander's type were the strongest risk factors

In 2014, Ulf JBrvholm et al. [84] conducted a study in which 20 patients with displaced intra articular fracture calcaneum managed with open reduction and postoperative early range of motion exercises were compared after 2-12 years with 19 patients who had similar fracture pattern but was managed conservatively. Both the groups were comparable regarding follow up time, age, sex distribution and preinjury occupation. Study shows that in both the groups, 3 patients had severe residual symptoms and equally many had negligible symptoms at follow up. Study also shows that in operated group patients had less reduced subtalar motion, better ability to run and jump, reduced forward tilting of the lateral part of the posterior articular surface and on uneven surface these patients can walk upto longer distance but these patients had only slightly improved Bohler angle. Although operative management had advantages like stability, allowing early motion and improved subtalar function but post operative complications were common. The overall result of open and closed calcaneum treatment was almost equal.

In 2014, Prasad K et al. [85] study was conducted to assess the functional outcome of conservatively treated and operatively treated intra articular fracture calcaneum. 25 intra articular fracture calcaneum were classified according to Sander's classification on the basis of Computerized tomography. out of 25 patients 11 were treated conservatively, 11 were treated operatively while 3 were treated with percutaneous screw fixation. it was concluded that Sander's type 1 can be managed conservatively with good functional outcome whereas Sander's type II and type III when managed conservatively results in satisfactory to poor functional outcome, hence for Sander's type II and type III open reduction and internal fixation with plating and bone grafting to be done for achieving excellent results .

In 2015, J.ashok et al. [1] conducted a combined retrospective and prospective study to evaluate outcome of surgically managed 26 intra articular fracture calcaneum on the basis of subjective, clinical and radiology criteria. It was seen that the mean age of the patients was 38 yrs. out of 26 intra articular fractures, 15 patients had sanders type 3 and 11 patients had sanders type 4 fracture pattern. Post operatively 6 patients had swelling, 9 patients suffered from persistent pain, 2 patients had superficial infection and one patient had deep infection. out of 26 patients excellent result was found in 5 patients, good result in 15 patients, fair in 4 patients and poor in 2 patients. They concluded that anatomic reduction and internal fixation is essential to allow early mobilization after operative management comminuted calcaneum fracture.

In 2016, Lian-hua Li et al. [86] conducted a prospective study to compare the outcome of sinus tarsi and extended lateral approaches for the surgical management of intra articular fracture calcaneum. 64 patients were selected and they were randomly assigned into 2 groups. 32 patients underwent sinus tarsi approach and 32 underwent lateral extensile approach. it was concluded that the wound complication rate was higher in lateral extensile approach as compared to sinus tarsi approach whereas no significant difference was found between the 2 groups on AOFAS scoring at 6 months and 1 year post operatively. Radiologically also with respect to Bohler angle at different times and reduction quality of articular surface no significant difference was found between the 2 groups.

In 2019, kawade et al. [87] conducted a study to evaluate the results of minimally invasive approach for intra articular and extra articular calcaneum facture. 30 patients were selected and managed with minimally invasive technique in both intra articular and extra articular fracture. After a follow up of 2 years, according to AOFAS scale 13 patients had excellent result and rest of the cases had good to fair results. None of the patient had wound infection, no skin necrosis, 5 patients had mild subtalar arthrosis and 3 patients had slight difficulty in wearing shoes. it was

concluded that minimally invasive technique will reduce the operative complication rates and in expert hand it can yield good results.

In 2019, Kumar R et al. [88] conducted a combined retrospective and prospective study to compare the outcome of conservatively treated and operatively treated intra articular fracture calcaneum on the basis of objective and subjective criteria 24 patients with 25 intra articular fracture calcaneum were included in study. Creighton – Nebraska scoring system was used for comparing the results. In type I conservative management had better outcome when compared with displaced fracture. In type 2 fracture pattern operative management had better outcome than non-operative treatment but difference was not statistically significant. In type 4 fracture pattern, operative management had statistically significant better outcome than non-operative management. Therefore it was conclude that conservative treatment is better for undisplaced fracture whereas operative management for anatomical reduction and restoration of Bohler angle was important in displaced and comminuted fracture.

In 2020, parvez et al. [89] conducted a study to evaluate the results of sinus tarsi approach for calcaneum fixation in terms of radiological and functional outcome. study was conducted in 30 patients, with both joint depression type and tongue type fractures, sander's type II AND type III Fracture. After a follow up period of 3 months, according to AOFAS scale 19 patients were having excellent result, 9 patients having good result and poor result was ssen in 2 patients. At 6 months of follow up ,28 patients have excellent results and 2 patients have good result. therefore, it was concluded that fixation of calcaneum fracture with plate using mippo technique through sinus approach is effective and safe method with good clinical and radiological results

In 2021, Tugrul bulut et al.[90] conducted a study to evaluate whether bone grafting (tri cortical iliac bone) provide extra benefit for stabilization of intra articular fracture calcaneum in SANDER'S type 3 and type 4 fixed with locking plate . 29 patients were included in the study and out of 29,

bone graft was used in 16 patients and in rest of the patients bone graft was not used. Clinical evaluation was performed using AOFAS score. No difference was seen in both the groups in terms of clinical results and radiological results. It was concluded that in sander's type 3 and type 4 fracture calcaneum fixed locking plate, bone grafting does not affect the clinical and radiological outcome. Also Bone grafting does not provide extra benefit in stability of fracture.

MATERIALS AND METHODS

SOURCE OF DATA

This study was a retrospective and prospective study to evaluate the union rates and complications of surgically managed fracture calcaneum. The patients operated at Dayanand Medical College & Hospital, Ludhiana from 1st Janurary, 2017 to march 2021 were included in this study. The performa was filled at the time of admission with demographic data and details of injuries recorded.

METHOD OF COLLECTION OF DATA

After obtaining approval from the institutional ethical committee, patients were enrolled in the study on the basis of inclusion / exclusion criteria. The study was carried out by taking an informed consent from the patients willing to be a part of the study.

Collection of data of patients presenting with calcaneum fractures was as follows

- History
- Clinical examination both systemic and local
- Radiological examination using Xray (LATERAL, AXIAL Views) And CT scan.
- Investigations - routine
- Diagnosis - clinical and radiological
- METHOD OF TREATMENT – Surgical management with locking compression plates (ORIF)
- Surgical: open reduction and Internal fixation with locking compression plates **was** done only after swelling subsides and wrinkle sign became positive.
- Routine - antibiotics and analgesics / anti inflammatory drugs
- Post op evaluation - clinical examination and xray (calcaneum - Axial and Lateral view)

Inclusion criteria:

1. All closed calcaneal fractures

Exclusion criteria:

1. Open fractures
2. Diabetic neuropathy
3. Peripheral vascular disease
4. Open calcaneal fracture part of crush injury

Data include was patient age and gender, mechanism of injury, date of injury, date of surgery, operative notes. In our study, Sander's classification was followed to classify the fractures. Follow up was done at 4 weeks, then at 3 months, and at 6^{th} months. Patients were assessed clinically for fracture healing, range of motion, and was radiographically checked for the progress of fracture healing. Radiographic union was defined as bridging trabeculations across the fracture site or absence of fracture line . Patients were assessed at final follow up after 6 months as per the AOFAS scoring system. In retrospective cases data was taken from patients records.

Duration of study:

- Prospective May 2019 to March 2021.
- Retrospective study January 2017 to April 2019.

Outcome: Final outcome was assessed using AOFAS SCORE.

AOFAS score at 6 months was taken as final functional outcome in all patients. Results were graded as Excellent (score - >90), Good (score – 75-89), FAIR (score – 60-74) or Poor (score - <60).

OBSERVATION AND RESULTS

This was a retrospective and prospective study in which all the patients presented to Dayanand Medical college & Hospital, Ludhiana with a diagnosis of closed fracture calcaneum between 1st Jan 2017 to March 2021 were included to look for the union rates and complications associated with surgically managed calcaneum fracture. The study included a total of 18 patients, out of which 16 were male patients and 2 were female patients.

TABLE 1: AGE DISTRIBUTION OF CALCANEUM FRACTURE PATIENTS

Age Group	No. of cases	Percentage (n=18)
15 - 30	6	33.33%
30 - 45	8	44.44%
45 - 60	4	22.22%

From the above table, it can be depicted that the incidence of calcaneum fracture was maximum in 30-45 years of age group with a mean age of 36.8 years, In our study, the youngest patient was 19 years old and oldest was 59 years old.

FIGURE 1: SHOWS THE AGE DISTRIBUTION OF THE CALCANEUM FRACTURE PATIENTS

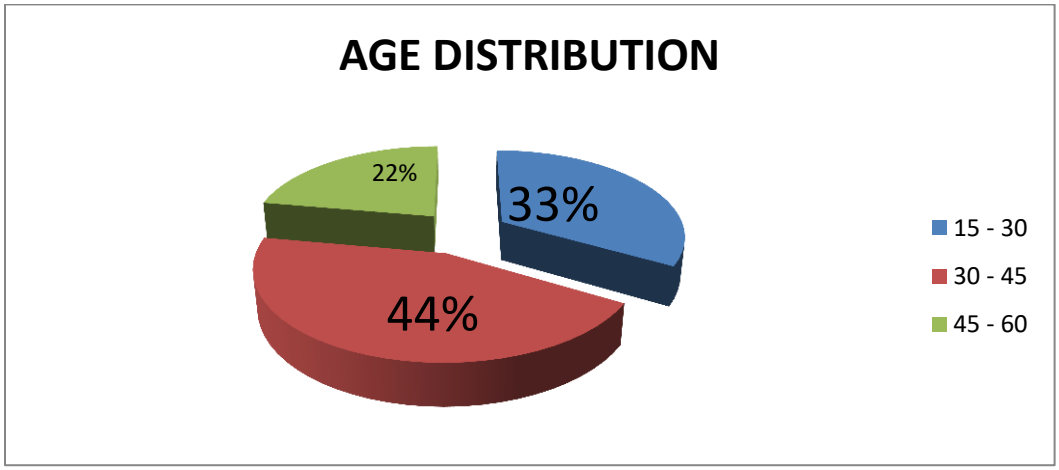


TABLE 2: GENDER DISTRIBUTION OF THE CALCANEUM FRACTURE PATIENTS

Sex	No. of cases	Percentage
M	16	88.9%
F	2	11.1%
Total	18	100.0%

From the above table, it can be depicted that the incidence of calcaneum fracture was more in males as compared to females. Out of total 18 patients, 16 were male 2 were females.

FIGURE 2: GENDER DISTRIBUTION OF THE CALCANEUM FRACTURE PATIENTS

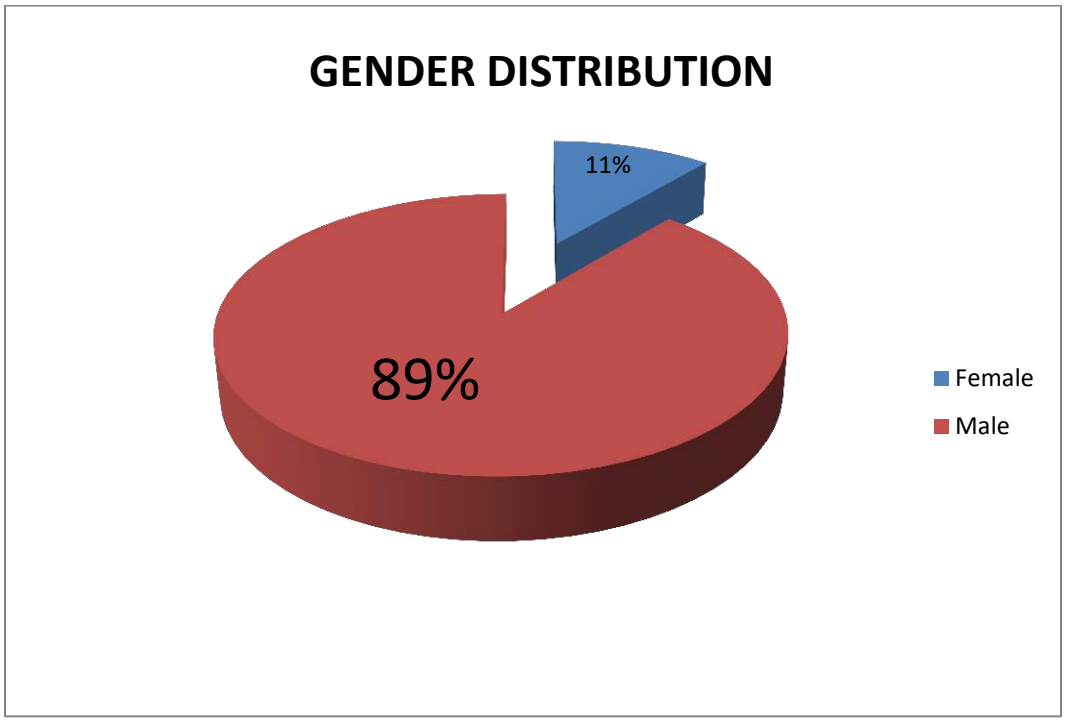


TABLE 3: MODE OF INJURY IN CALCANEUM FRACTURE PATIENTS

Mode of injury	No. of cases	Percentage
FALL FROM HEIGHT	16	88.9%
RSA	2	11.1%
Total	18	100.0%

From the above table, it can be depicted that fall from height was the most common mode of injury in calcaneum fracture patients. Out of 18 patients, the mode of injury in 16 patients was fall from height and in remaining 2 patients it was due to roadside accident.

FIGURE 3: MODE OF INJURY IN CALCANEUM FRACTURE PATIENTS

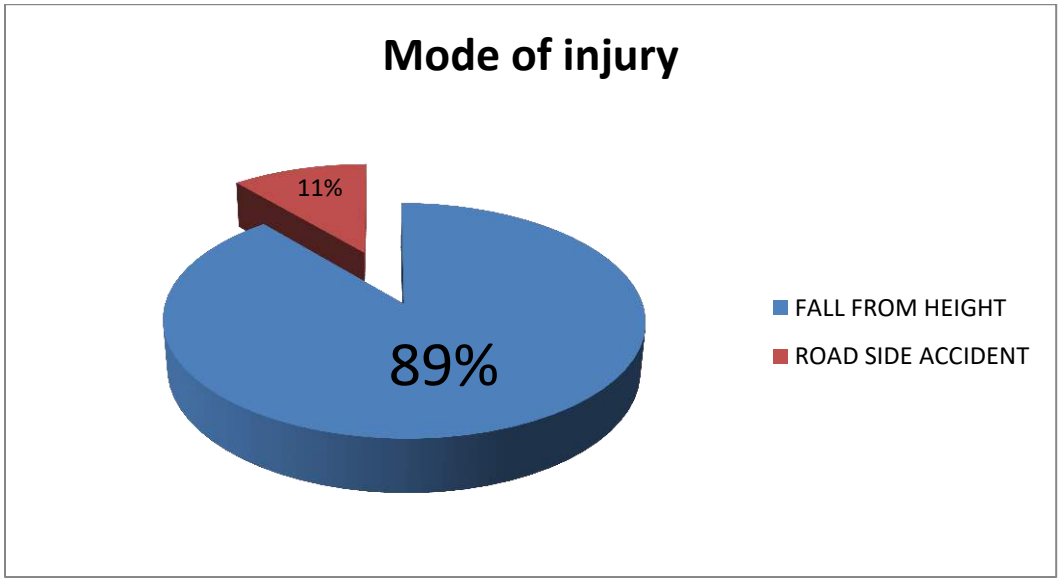


TABLE 4. DISTRIBUTION ACCORDING TO SIDE OPERATED.

SIDE OPERATED	No. of cases	Percentage
LEFT	8	44.4%
RIGHT	10	55.6%
Total	18	100.0%

In our study, out of 18 patients, 8 patients has been operated for left side and 10 patients has been operated for right side

FIGURE 4. DISTRIBUTION ACCORDING TO SIDE OPERATED.

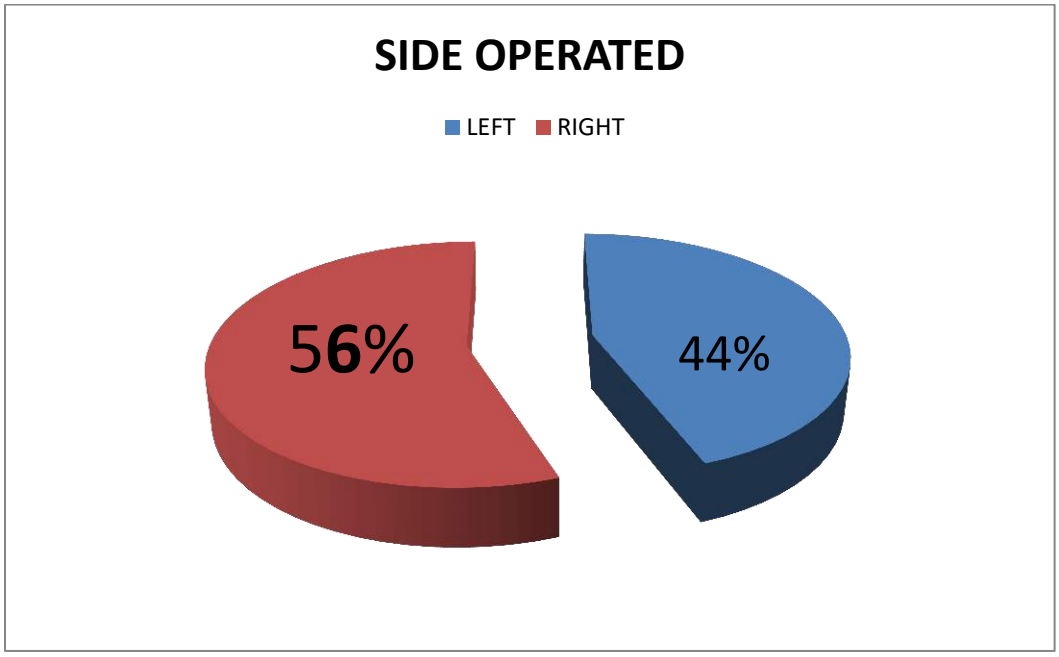


TABLE 5. ASSOCIATION OF CALCANEUM FRACTURE WITH SPINE INJURY

Association with spine injury	No. of cases	Percentage
Yes	6	33.3%
No	12	66.7%
Total	18	100.0%

Out of total 18 patients, 6 (33.3%) patients had calcaneum fracture associated with spine injury. Therefore the patient with calcaneum fracture should be screened for spine injury also.

FIGURE 5. ASSOCIATION OF CALCANEUM FRACTURE WITH SPINE INJURY

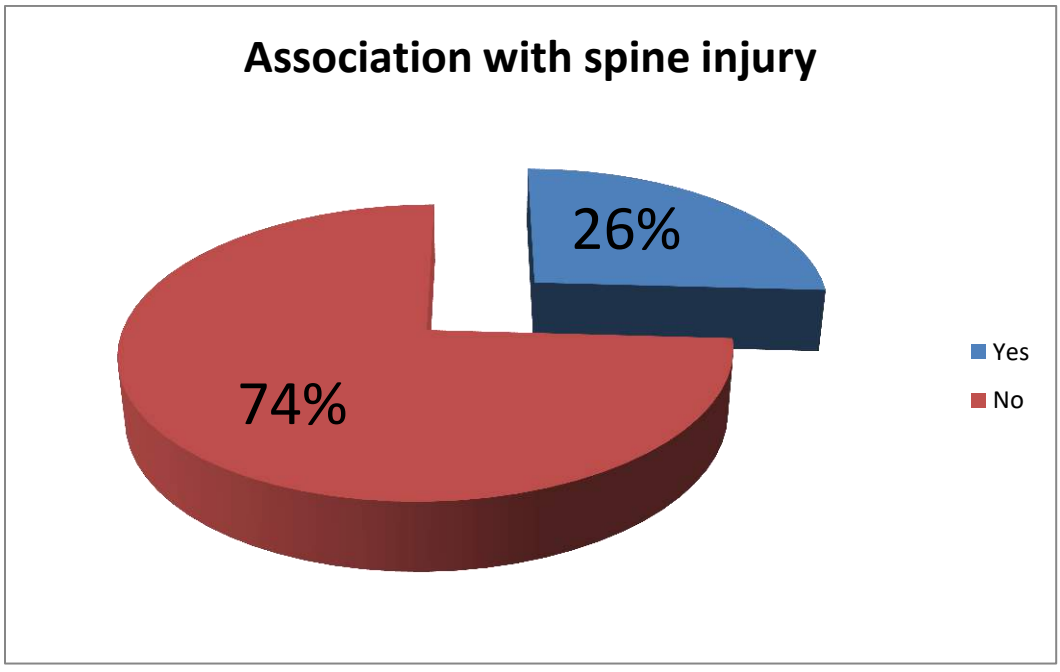


TABLE 6. BILATERAL INVOLVEMENT OF CALCANEUM FRACTURE

BILATERAL CALCANEUM INVOLVEMENT	No. of cases	Percentage
PRESENT	6	33.3%
ABSENT	12	66.7%
Total	18	100.0%

In our study, it had been observed that out of 18 patients, 6 patients had bilateral calcaneum involvement and remaining 12 had unilateral involvement.

FIGURE 6. BILATERAL INVOLVEMENT OF CALCANEUM FRACTURE

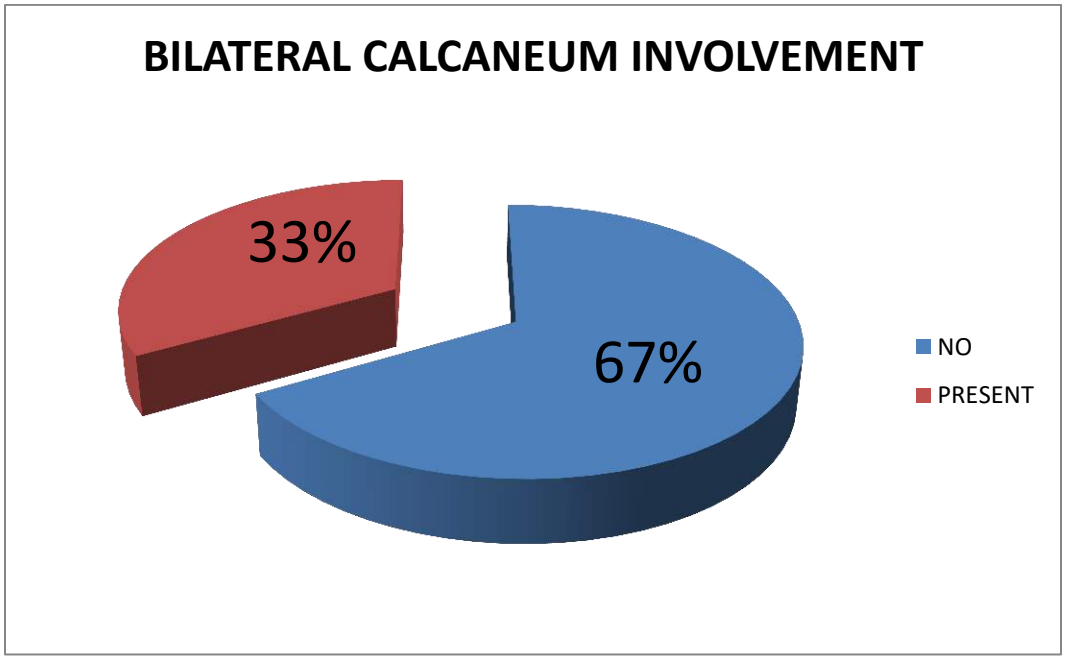


TABLE 7. PAST HISTORY OF PATIENTS WITH CALCANEUM FRACTURE.

Past H/O	No. of cases	Percentage
DIABETES MELLITUS	1	5.55%
HYPERTENSION	4	22.22%
NIL	13	72.22%

In this study, out of total 18 patients , there were 4 patients of hypertension , 1 patient of diabetes mellitus and rest of the others didn't had an any relavent past history .

FIGURE 7. PAST HISTORY OF PATIENTS WITH CALCANEUM FRACTURE.

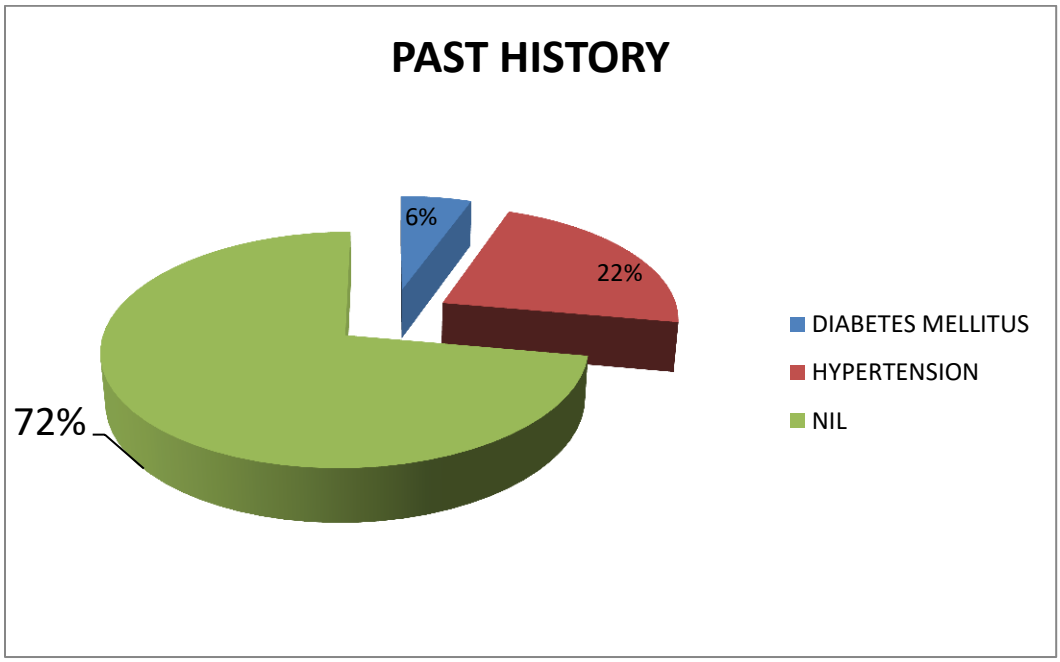


TABLE 8 . DISTRIBUTION OF FRACTURE CALCANEUM PATIENTS ACCORDING TO FRACTURE UNION TIME .

Union time	No. of cases	Percentage
<11	10	55.55%
12-14	7	38.88%
>14	1	5.55%
Total	18	100%

From the above table it can be depicted that out of 18 patients, 10 had union of fracture with in or equal to 11 weeks while 7 patients had union of fracture between 12-14 weeks and only 1 patient had delayed union. The average union time of fracture in our study was 12 weeks .

FIGURE 8 . DISTRIBUTION OF FRACTURE CALCANEUM PATIENTS ACCORDING TO FRACTURE UNION TIME .

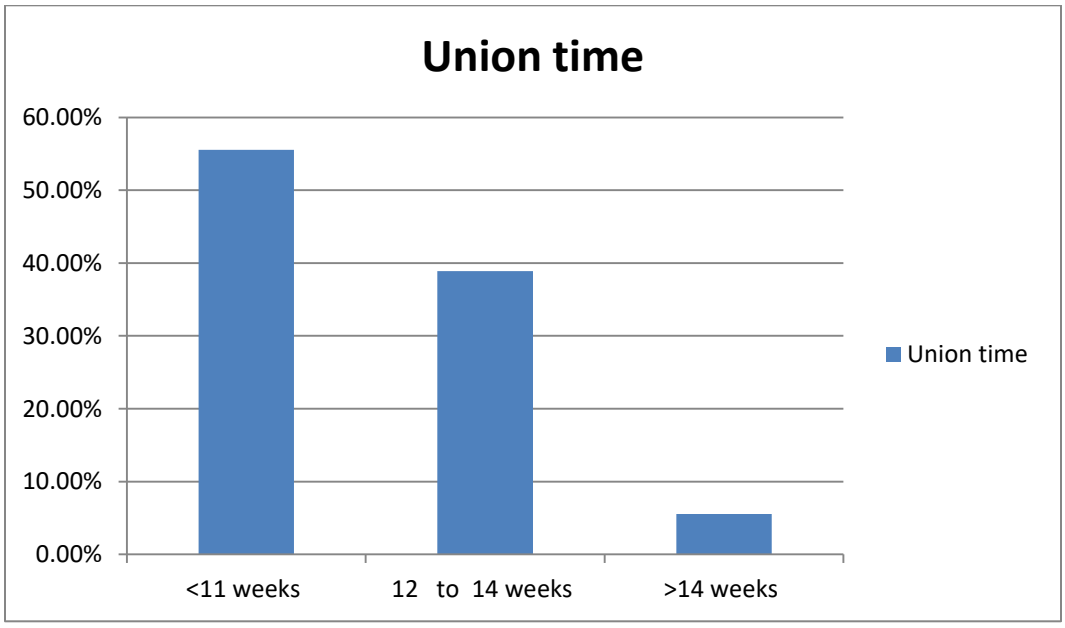


TABLE 9. DISTRIBUTION OF FRACTURE CALCANEUM PATIENTS ACCORDING TO USE OF BONE SUBSTITUTE.

	Number of patients	Percentage
Bone substitute used	4	22.22%
Bone substitute not used	14	77.77%
Total	18	100%

In our study, bone substitute was used in 4 patients out of 18 total patients. No significant difference was found in these 4 bone substitute patients when compared with other 14 patients in term of reduction, AOFAS score, union time, healing time, post operative complications.

FIGURE 9. DISTRIBUTION OF FRACTURE CALCANEUM PATIENTS ACCORDING TO USE OF BONE SUBSTITUTE.

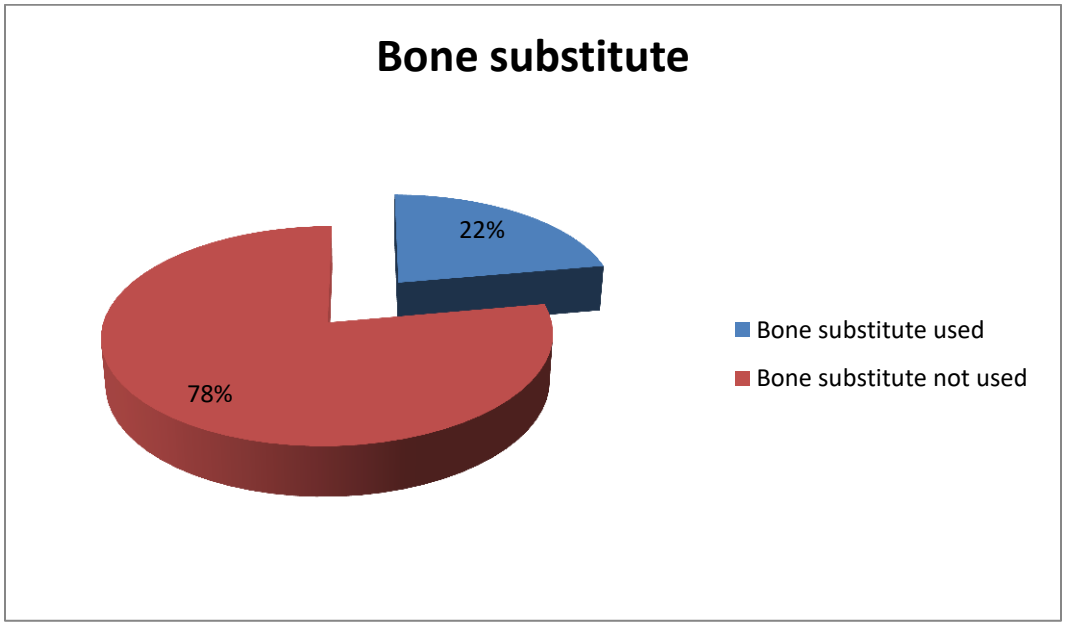


TABLE 10. TIME GAP BETWEEN CALCANEUM INJURY AND SURGERY. (ORIF)

NO. OF DAYS BETWEEN INJURY AND SURGERY DONE	No. of cases	Percentage
0-7 days	4	22.2%
8-14 days	4	22.2%
15-21 days	5	27.7%
>or equal to 22 days	5	27.7%
Total	18	100.0%

In our study, it was observed that the majority of the patients (72.2%) had been operated within first 3 weeks of the calcaneum injury. While rest of the 5 patients has operated after 21 days from date of injury. Out of these 5 late operated patients 3 were Covid positive.

FIGURE 10. TIME GAP BETWEEN CALCANEUM INJURY AND SURGERY. (ORIF)

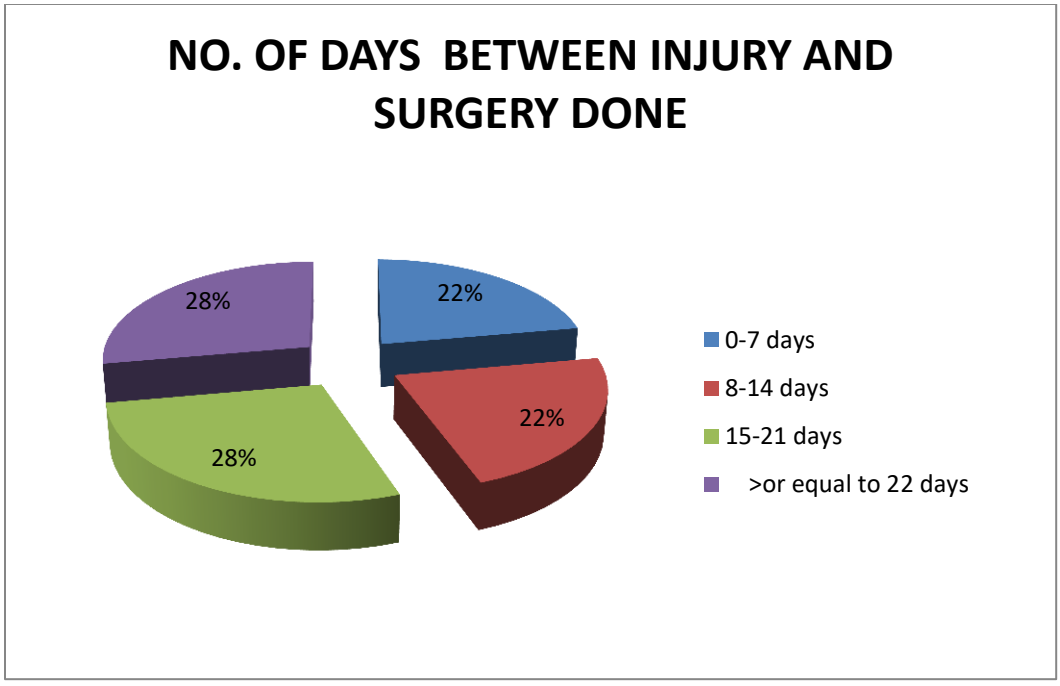


TABLE 11. PREOPERATIVE AND POST OPERATIVE BOHLER'S ANGLE IN CALCANEUM FRACTURE PATIENTS

BOHLER'S ANGLE **(Degree)**	PRE OP	POST OP
Less than or equal to 9	7	1
Between 10-19	10	6
Between 20-40	1	11

In our study, it was observed that out of 18 patients, preoperatively 7 patients had Bohler angle less than or equal to 7 while post operative this number decreases to 1. 10 patients had preoperative Bohler angle between 10-19 degree while this number decreases to 6 post operatively and lastly 1 patient had pre operative Bohler angle between 20-40 degree while in post operative this number increases to 11. in our study the post operative mean Bohler's angle was 21.3 degree.

TABLE 11. PREOPERATIVE AND POST OPERATIVE BOHLER'S ANGLE IN CALCANEUM FRACTURE PATIENTS

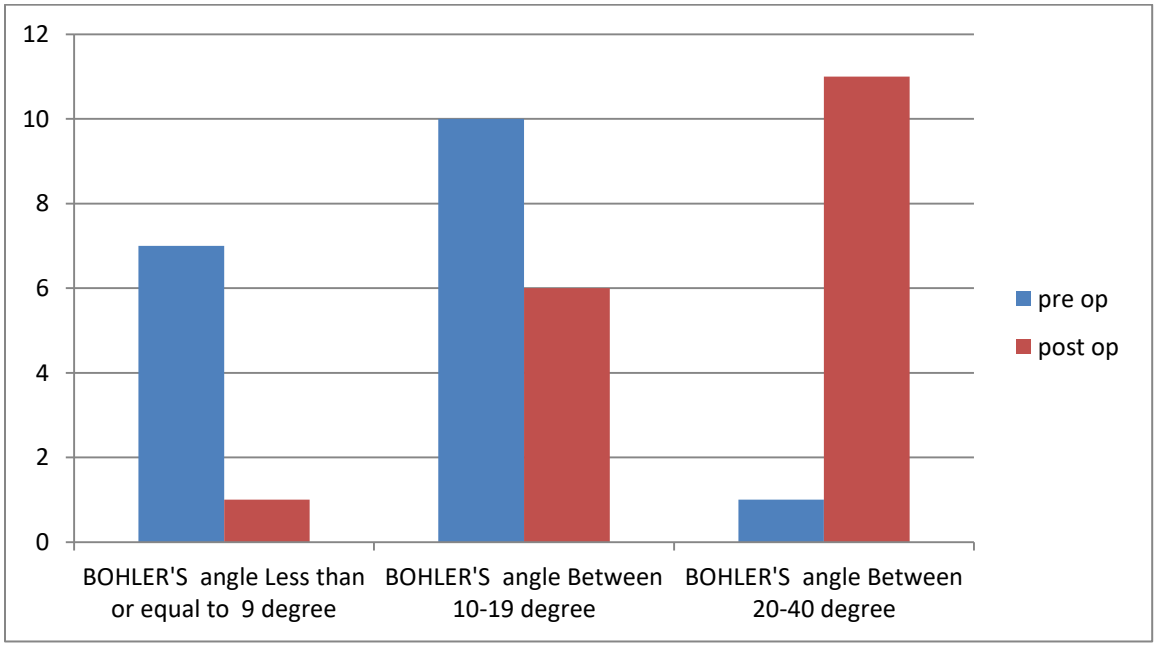


TABLE 12. PRE OPERATIVE AND POST OPERATIVE GISSANE'S ANGLE IN CALCANEUM FRACTURE PATIENTS

Gissane's angle **(Degree)**	PRE OP	POST OP
Less than or equal to 119	5	7
Between 120 -139	7	11
More than 140	6	0

In our study ,it was observed that out of 18 patients, pre operatively 5 patients had Gissane 's angle less than or equal to 119 while post operative this number increases to 7. 7 patients had preoperative Gissane 's angle between 120-139 degree while this number increases to 11 post operatively and lastly 6 patient had pre operative Gissane's angle more than 140 degree while in post operative this number decreases to 0. In our study the post operative mean Gissane's angle was 122.6 degree.

FIGURE 12. PRE OPERATIVE AND POST OPERATIVE GISSANE'S ANGLE IN CALCANEUM FRACTURE PATIENTS

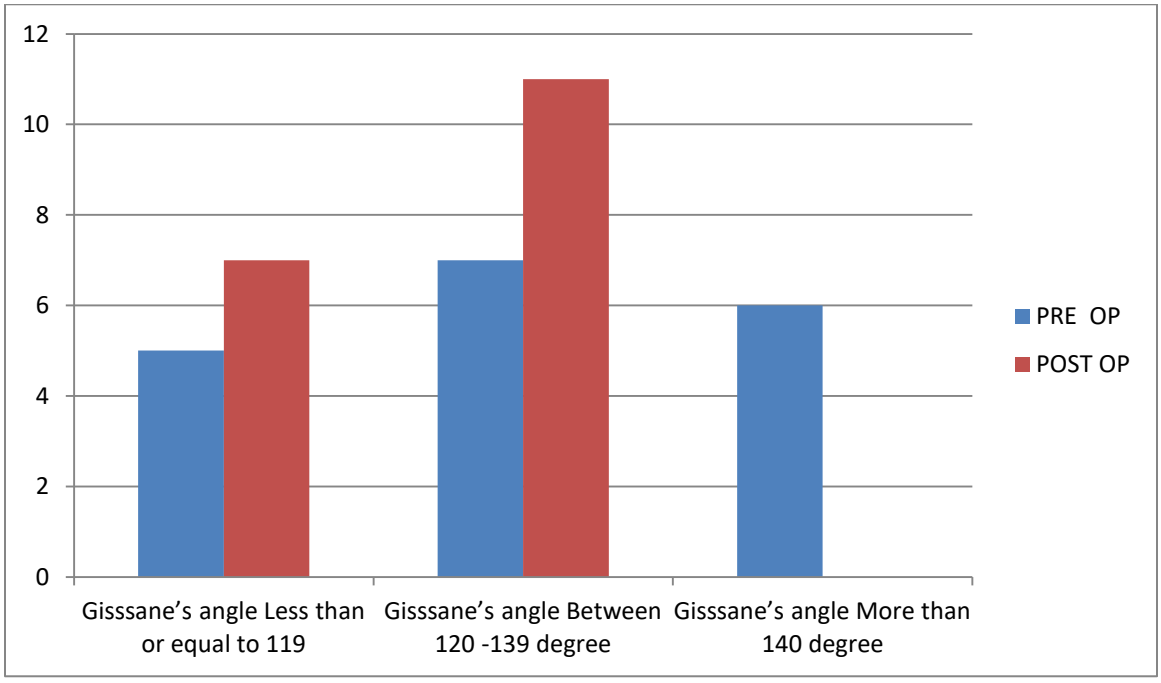


TABLE 13. RANGE OF DORSIFLEXION IN FRACTURE CALCANEUM PATIENTS

Dorsiflexion (Degree)	No. of cases	Percentage
UPTO 10	13	72.2%
MORE THAN 10	5	28.8%
Total	18	100.0%

In our study, out of total 18 patients 13 patients had dorsiflexion of upto 10 degree whereas rest of the patients had dorsiflexion of more than 10 degree. The Mean Dorsiflexion In Our Study Is 11.11 Degree

FIGURE 13. RANGE OF DORSIFLEXION IN FRACTURE CALCANEUM PATIENTS

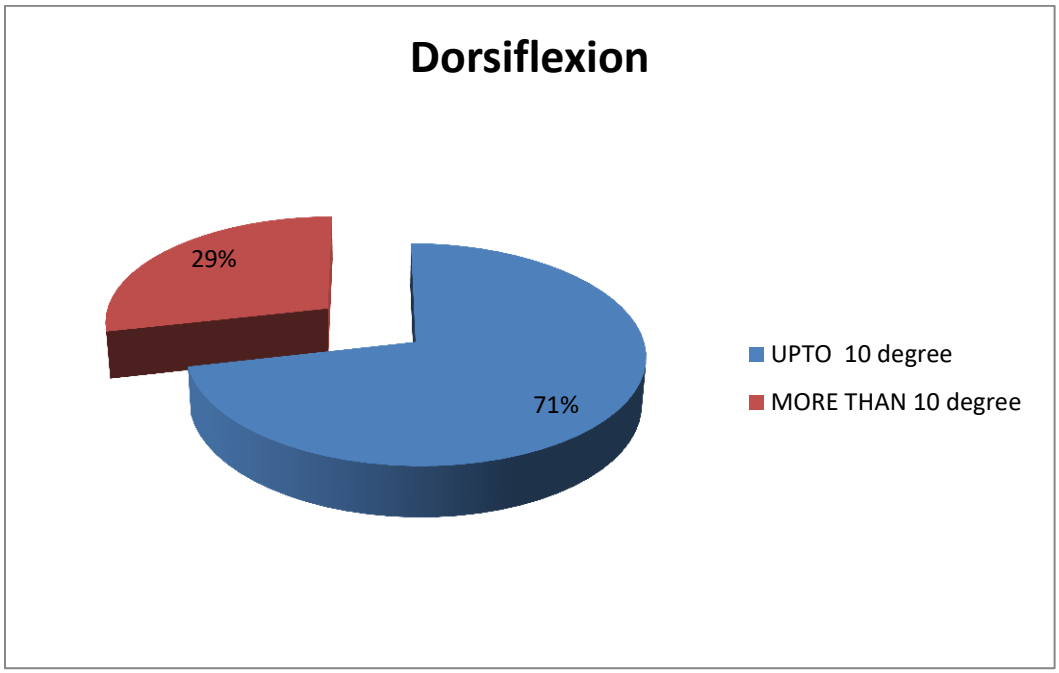


TABLE 14. RANGE OF PLANTARFLEXION IN FRACTURE CALCANEUM PATIENTS

Plantarflexion (Degree)	No. of cases	Percentage
UPTO 15	7	38.8%
BETWEEN 16-30	11	61.2%
MORE THAN 30	0	0%
Total	18	100.0%

In our study, out of total 18 patients 7 patients had plantar flexion of upto 15 degree while remaining 11 patients had plantarflexion between 16-30 degree. The mean plantarflexion in our study is 20.05 degree.

FIGURE 14. RANGE OF PLANTARFLEXION IN FRACTURE CALCANEUM PATIENTS

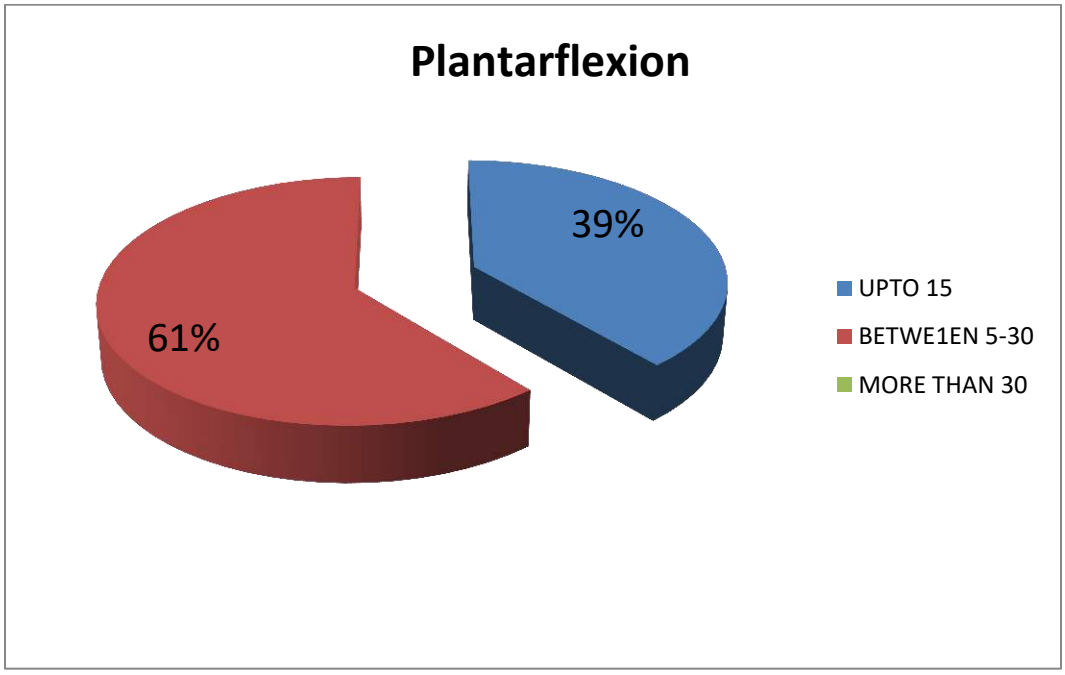


TABLE 15. RANGE OF EVERSION IN FRACTURE CALCANEUM PATIENTS

Eversion (Degree)	No. of cases	Percentage
UPTO 10	12	72.2%
MORE THAN 10	6	27.8%
Total	18	100.0%

In our study, out of 18 patients 12 patients had eversion upto 10 degree while rest of the patients had eversion of more than 10 degree. The mean eversion in our study was 9.05 degree

FIGURE 15. RANGE OF EVERSION IN FRACTURE CALCANEUM PATIENTS

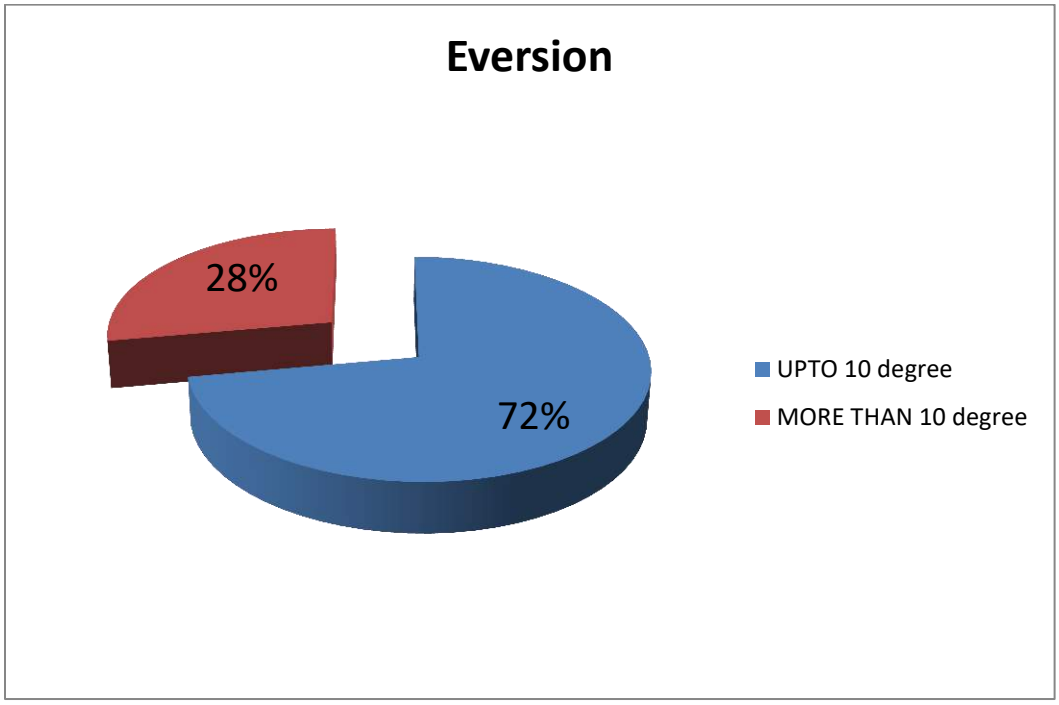


TABLE 16. RANGE OF INVERSION IN FRACTURE CALCANEUM PATIENTS

Inversion (Degree)	No. of cases	Percentage
UPTO 15	9	50%
BETWEEN 16-30	9	50%
Total	18	100.0%

In our study, out of 18 patients 9 patients had inversion upto 15 degree while rest of the patients had inversion between 16-30 degree. The mean inversion in our study was 15.8 degree

FIGURE 16. RANGE OF INVERSION IN FRACTURE CALCANEUM PATIENTS

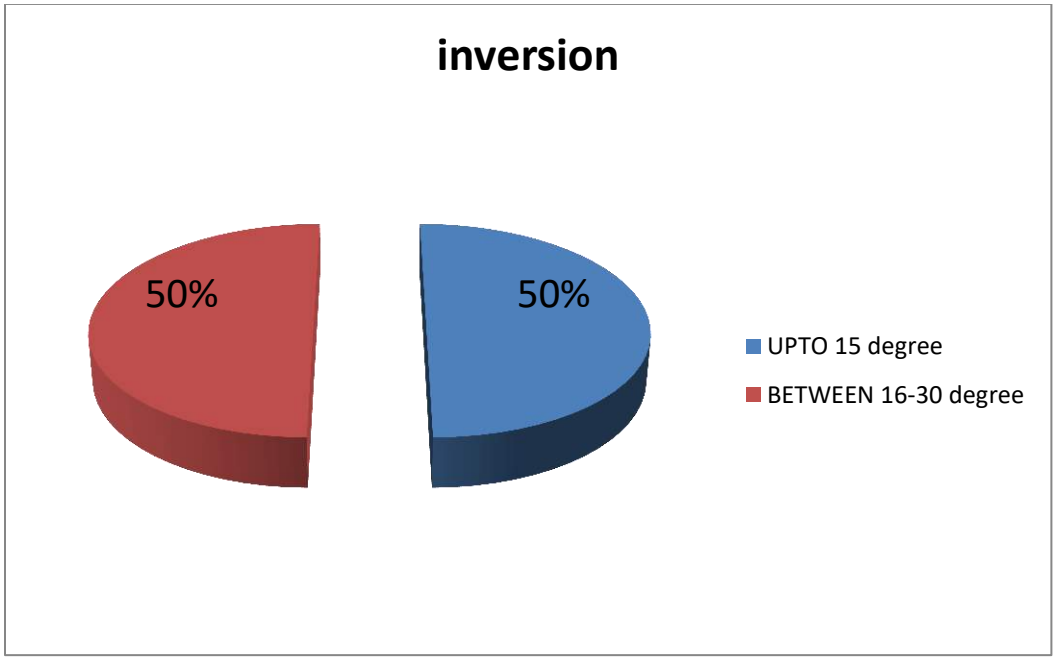


TABLE 17. DISTRIBUTION OF CALCANEUM FRACTURE ACCORDING TO THE SANDER'S CLASSIFICATION

Sander's Classifications	No. of cases	Percentage
Type I	0	0.0%
Type II	6	33.3%
Type III	10	55.6%
Type IV	2	11.1%
Total	18	100.0%

In our study, it was observed that most of the calcaneum fracture fall under type III followed by type II followed by type IV of Sander's classification

FIGURE 17. DISTRIBUTION OF CALCANEUM FRACTURE ACCORDING TO THE SANDER'S CLASSIFICATION

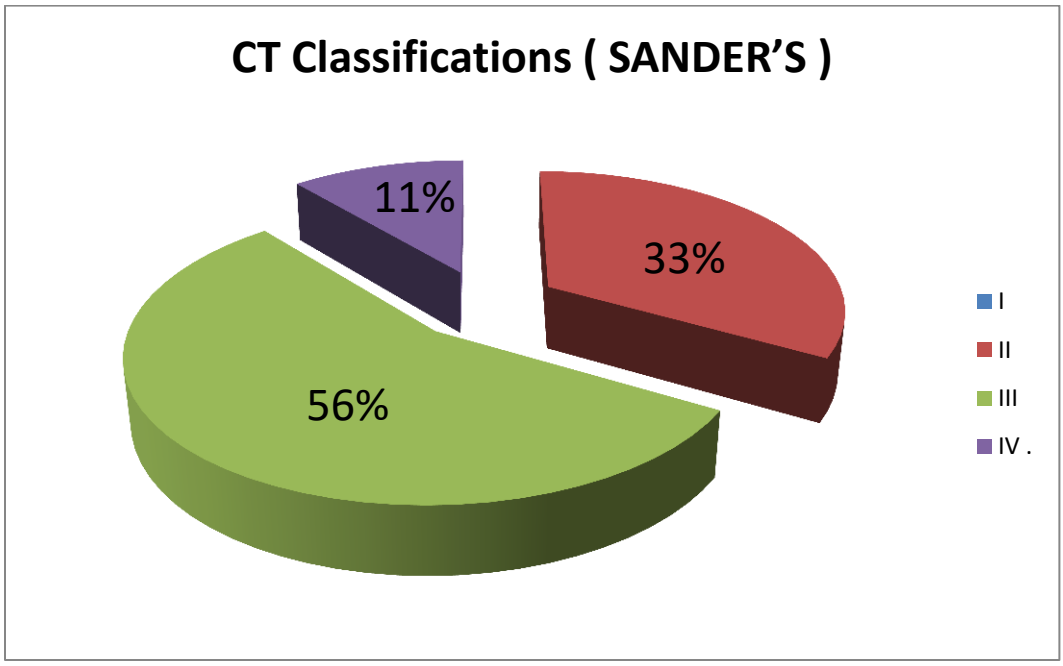


TABLE 18. DISTRIBUTION OF CALCANEUM FRACTURE PATIENTS ACCORDING TO PAIN.

Pain	No. of cases	Percentage
Moderate	3	16.7%
Mild or occasional	13	72.2%
No pain	2	11.1%
Total	18	100.0%

The above table depicts that after post operative period of 6 months out of 18 patients 13 were having mild pain or occasional pain, 3 were having moderate pain and 2 were having no pain.

FIGURE 18. DISTRIBUTION OF CALCANEUM FRACTURE PATIENTS ACCORDING TO PAIN

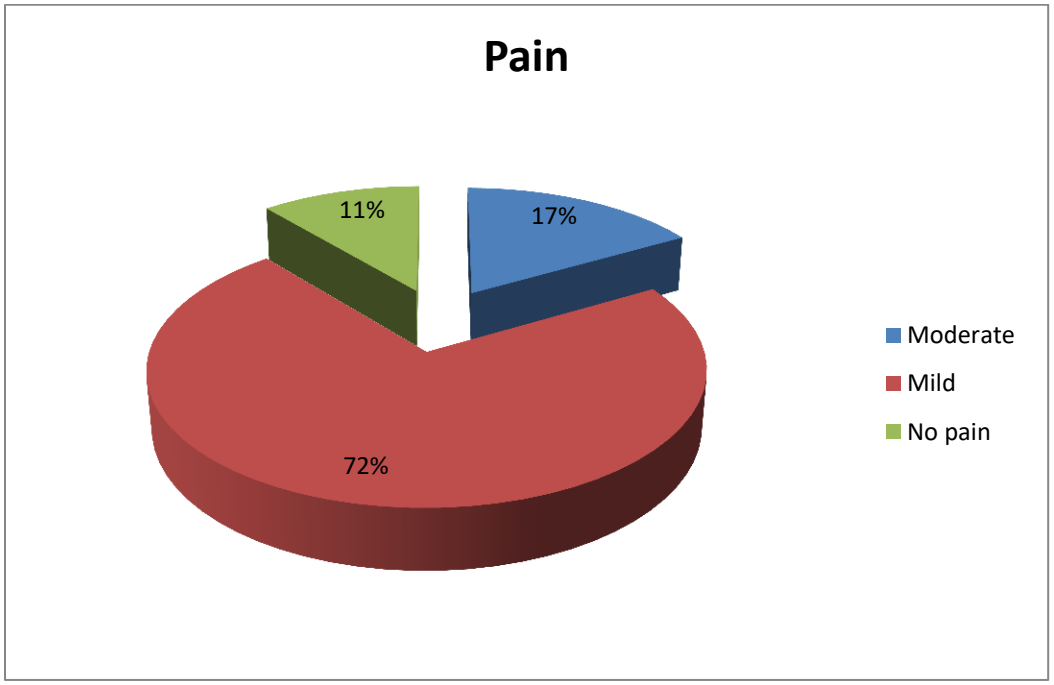


TABLE 19. DISTRIBUTION OF CALCANEUM FRACTURE PATIENTS ACCORDING TO FUNCTIONAL ACTIVITY.

FUNCTIONAL ACTIVITY	No. of cases	Percentage
Limited daily and recreational activity	5	27.7%
Limitation of recreational activity only	11	61.11%
No limitation, no support	2	11.1%
Total	18	100.0%

In our study, it was observed that out of 18 patients of fracture calcaneum, 11 have limitation of recreational activity, 5 have limited daily and recreational activity and only 2 have no limitation of activity or required no support

FIGURE 19. DISTRIBUTION OF CALCANEUM FRACTURE PATIENTS ACCORDING TO FUNCTIONAL ACTIVITY.

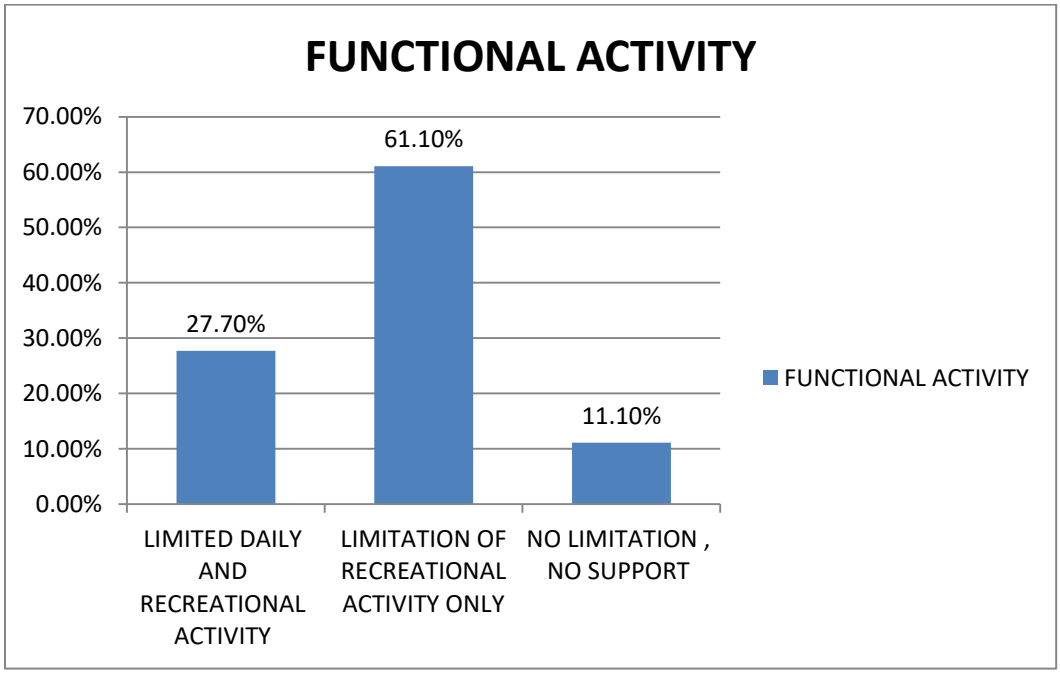


TABLE 20. DISTRIBUTION OF CALCANEUM FRACTURE PATIENTS ACCORDING TO THE MAXIMUM WALKING DISTANCE

MAXIMUM WALKING DISTANCE (BLOCKS)	No. of cases	Percentage
1-3 BLOCKS	13	72.2%
4-6 BLOCKS	5	27.8%
Total	18	100.0%

In our study, it was observed that out of 18 patients, 13 patients can walk upto 3 blocks only comfortably, whereas rest of the patients can able to walk upto 6 blocks comfortably.

FIGURE 20. DISTRIBUTION OF CALCANEUM FRACTURE PATIENTS ACCORDING TO THE MAXIMUM WALKING DISTANCE

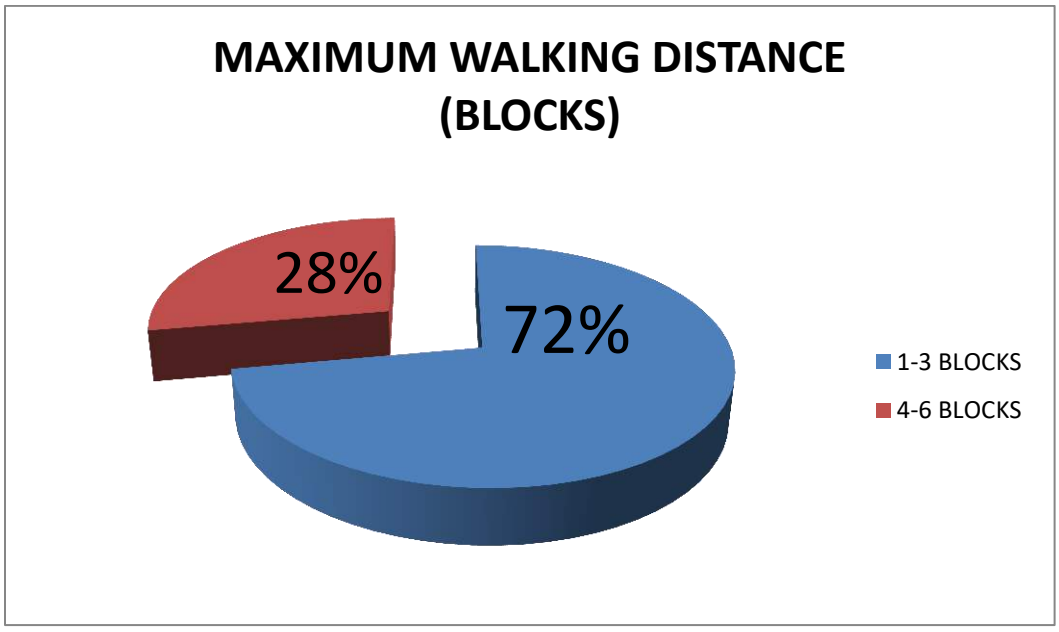


TABLE 21. DISTRIBUTION OF CALCANEUM FRACTURE PATIENTS ACCORDING TO WALKING DIFFICULTY ON UNEVEN SURFACE.

WALKING SURFACES	No. of cases	Percentage
SEVERE DIFFICULTY ON UNEVEN TERRAIN, STAIRS	3	16.7%
SOME DIFFICULTY ON UNEVEN TERRAIN, STAIRS	13	72.2%
NO DIFFICULTY ON ANY SURFACE	2	11.1%
Total	18	100.0%

In our study, it was observed that 13 out of 18 patients had some difficulty while walking on uneven terrain or stairs, 3 out of 18 patients had severe difficulty while walking on uneven terrain or stairs and 2 patients out of 18 had no difficulty while walking on uneven terrain or stairs.

FIGURE 21. DISTRIBUTION OF CALCANEUM FRACTURE PATIENTS ACCORDING TO WALKING DIFFICULTY ON UNEVEN SURFACE.

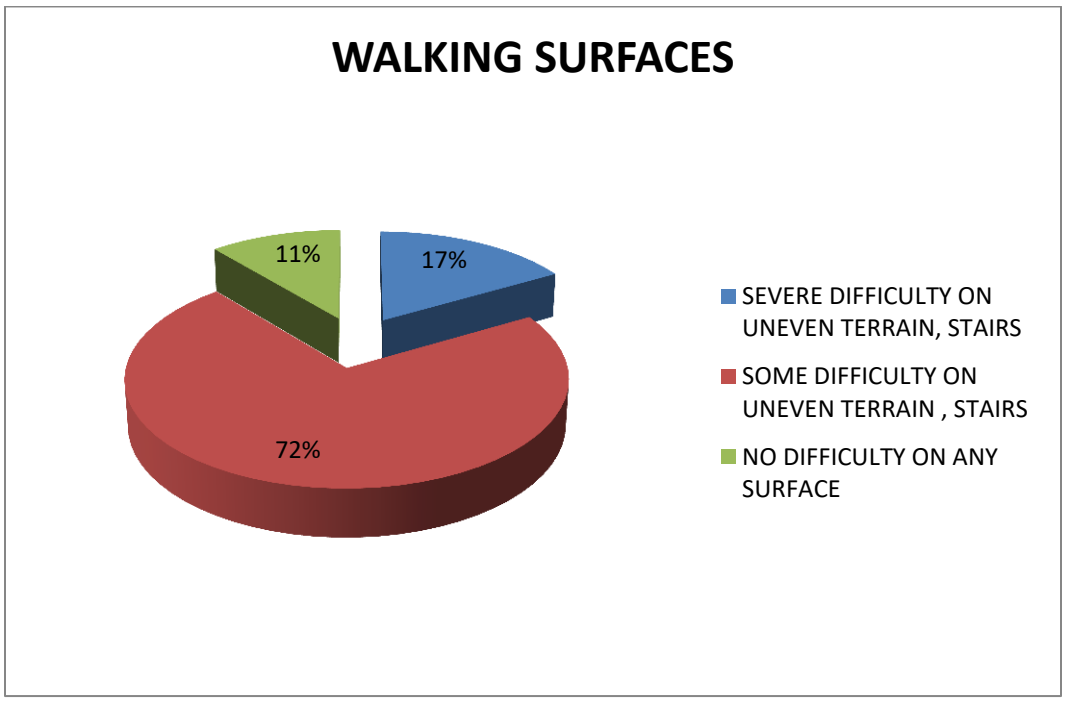


TABLE 22. DISTRIBUTION OF GAIT ABNORMALITY IN FRACTURE CALCANEUM PATIENTS

GAIT ABNORMALITY	No. of cases	Percentage
OBVIOUS GAIT ABNORMALITY	3	16.66%
NONE, SLIGHT GAIT ABNORMALITY	15	83.3%
Total	18	100.0%

In our study, out of 18 calcaneum fracture patients, 3 patients had obvious gait abnormality while rest of the 15 patients had slight or no gait abnormality .

FIGURE 22. DISTRIBUTION OF GAIT ABNORMALITY IN FRACTURE CALCANEUM PATIENTS

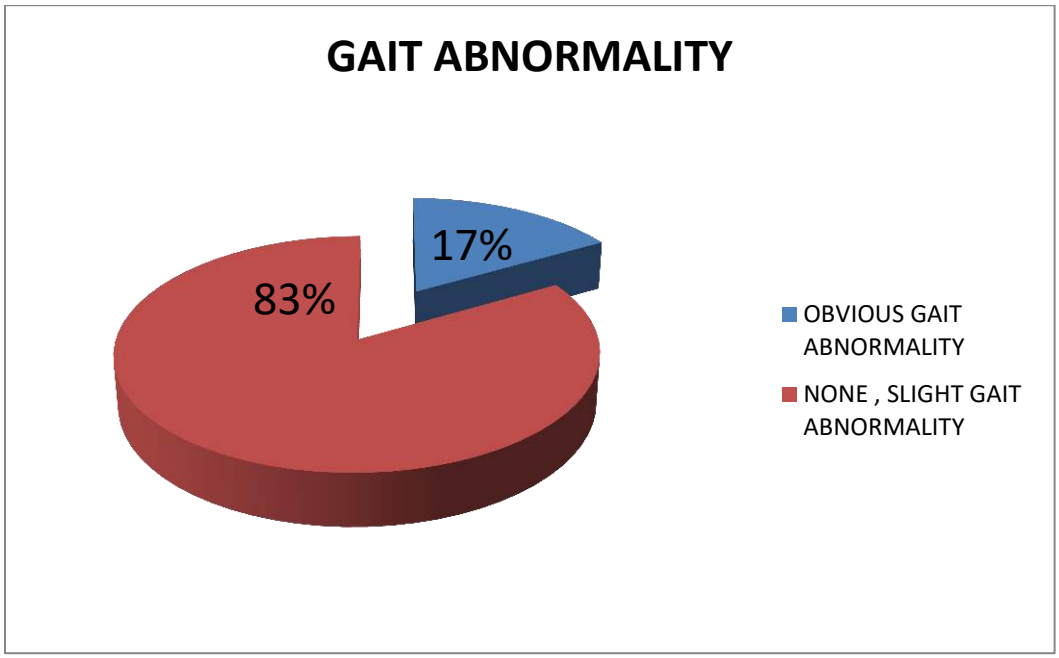


TABLE 23. SHOWS THE SAGGITAL PLANE MOTION IN CALCANEUM FRACTURE PATIENTS

SAGGITALMOTION (FLEXION PLUS EXTENSION)	No. of cases	Percentage
SEVERE RESTRICTION	0	0.0%
MODERATE RESTRICTION OF MOTION	7	38.9%
NORMAL OR MILD RESTRICTION OF MOTION	11	61.1%
Total	18	100.0%

In our study, it was observed that out of 18 patients, 11 patients had normal or mild restriction of motion in saggital plane while rest of the 7 patients had moderate restriction of motion in saggital plane

FIGURE 23. SHOWS THE SAGGITAL PLANE MOTION IN CALCANEUM FRACTURE PATIENTS

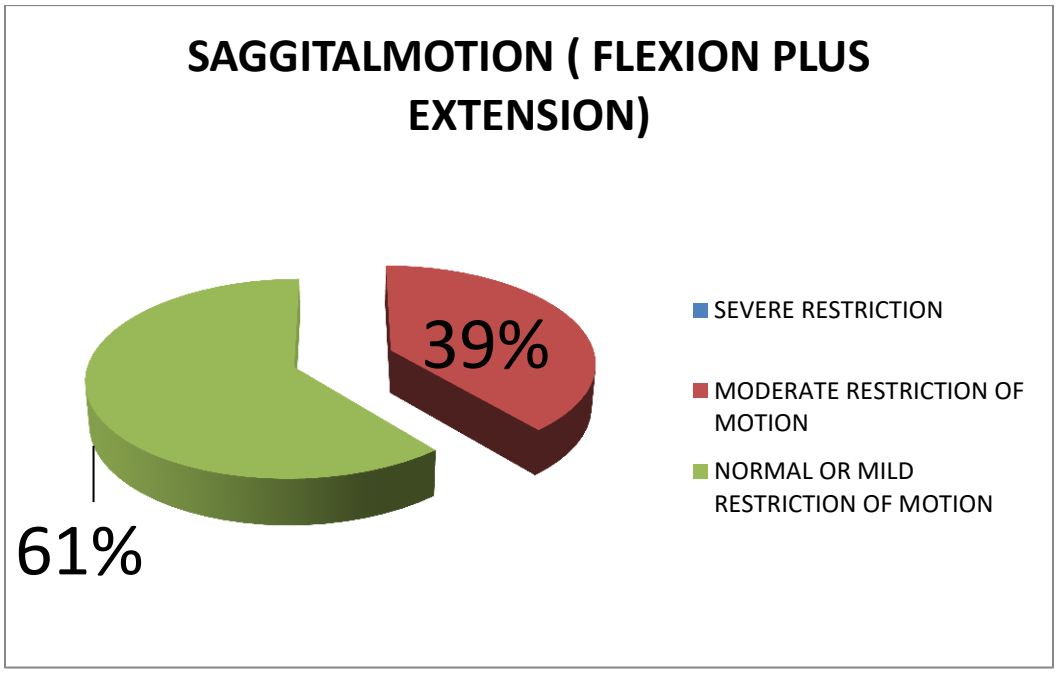


TABLE 24. HIND FOOT MOTION IN CALCANEUM FRACTURE PATIENTS

HIND FOOT MOTION	No. of cases	Percentage
MARKED RESTRICTION	4	22.3%
MODERATE RESTRICTION	14	77.7%
NORMAL OR MILD RESTRICTION	0	0.00%
Total	18	100.0%

In our study, it was observed that 14 out of 18 patients had moderate restriction in hind foot motion while 4 out of 18 patients had marked restriction in hind foot motion.

FIGURE 24. HIND FOOT MOTION IN CALCANEUM FRACTURE PATIENTS

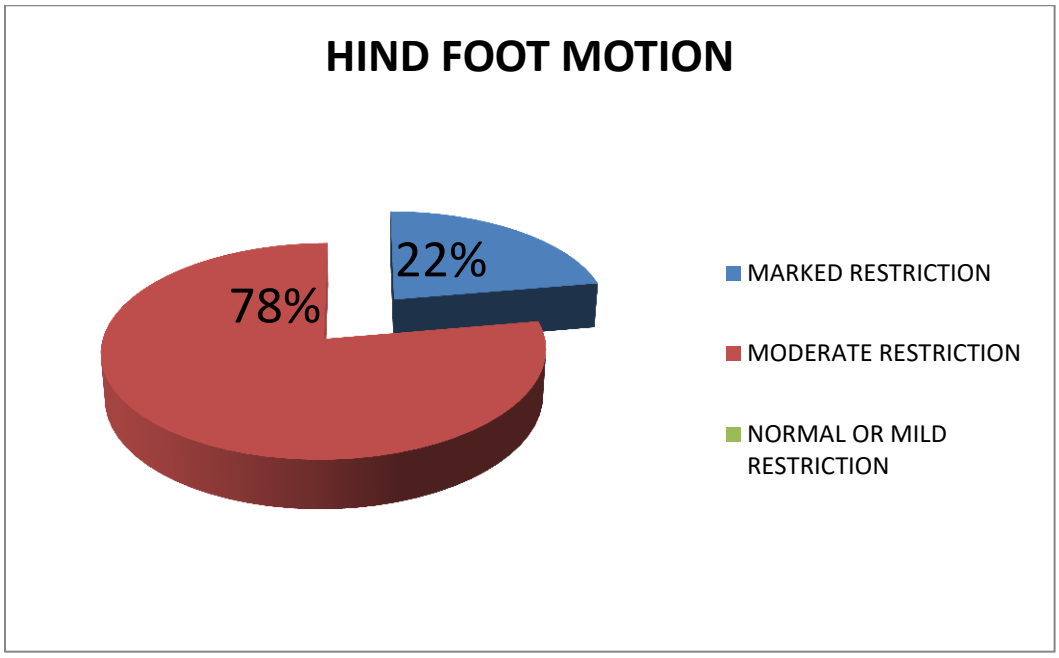


TABLE 25. ANKLE HINDFOOT STABILITY IN CALCANEUM FRACTURE PATIENTS

ANKLE HINDFOOT STABILITY	No. of cases	Percentage
DEFINITELY UNSTABLE	3	16.66%
STABLE	15	83.33%
Total	18	100.0%

In our study , out of 18 patients ankle hindfoot stability was present in 15 patients whereas ankle hindfoot unstability was present in 3 patients.

FIGURE 25. ANKLE HINDFOOT STABILITY IN CALCANEUM FRACTURE PATIENTS

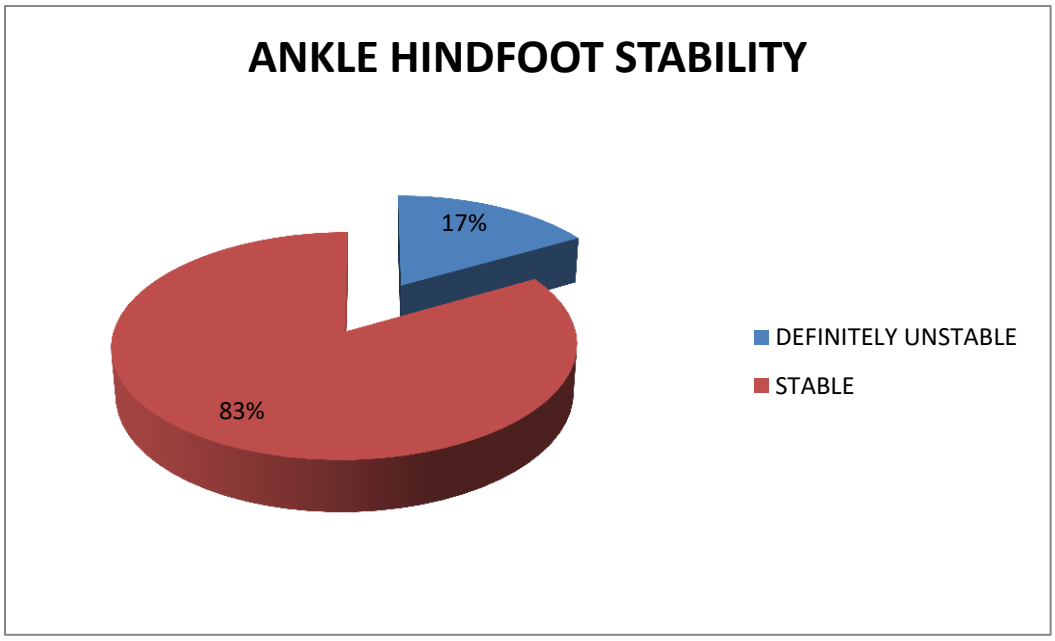


TABLE 26. ALIGNMENT OF HIND FOOT IN CALCANEUM FRACTURE PATIENTS

ALIGNMENT	No. of cases	Percentage
FAIR, PLANTIGRADE FOOT, ANKLE HIND FOOT WELL ALIGNED	15	83.3%
FAIR, PLANTIGRADE FOOT, SOME DEGREE OF ANKLE HIND FOOT MALALIGNMENT	3	16.7%
POOR, NON PLANTIGRADE FOOT, SEVERE MALALIGNMENT	0	0.00%
Total	18	100.0%

In our study , out of total 18 patients 15 patients had well aligned ankle hindfoot and only 3 patients had some degree of ankle hindfoot malalignment .

FIGURE 26. ALIGNMENT OF HIND FOOT IN CALCANEUM FRACTURE PATIENTS

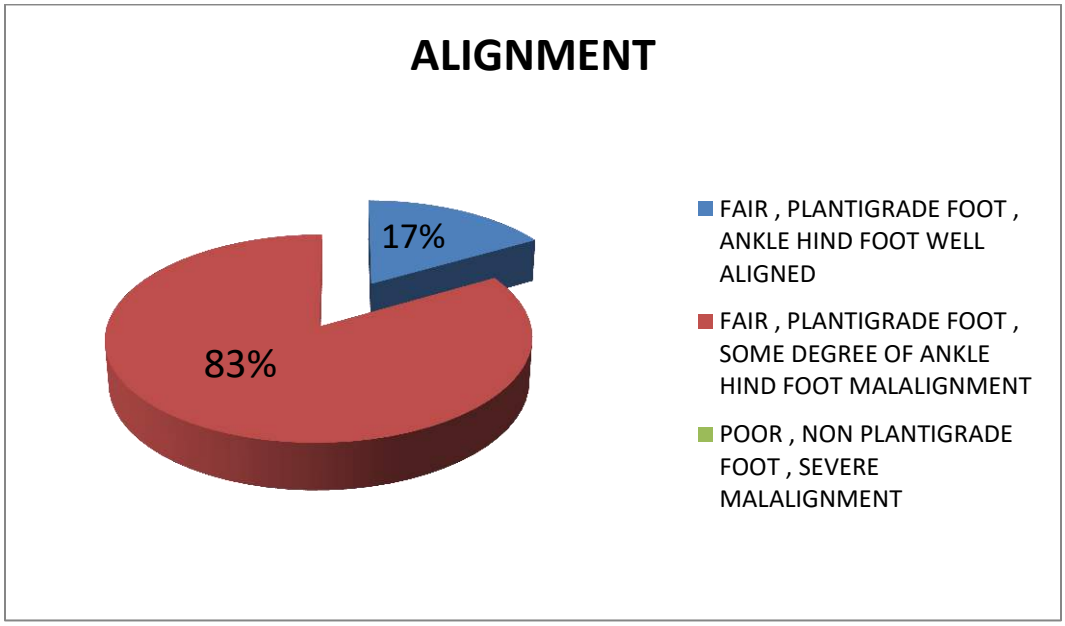

ALIGNMENT
17%
83%
FAIR , PLANTIGRADE FOOT , ANKLE HIND FOOT WELL ALIGNED
FAIR , PLANTIGRADE FOOT , SOME DEGREE OF ANKLE HIND FOOT MALALIGNMENT
POOR , NON PLANTIGRADE FOOT , SEVERE MALALIGNMENT

TABLE 27. RESULTS OF SURGICALLY MANAGED FRACTURE CALCANEUM

Results	No. of cases	Percentage
EXCELLENT	2	11.1%
FAIR	6	33.3%
GOOD	8	44.44%
POOR	2	11.1%
Total	18	100.0%

In our study out of total 18 patients, 2 patients had excellent result, 8 patients had good result, 6 patients had fair result and 2 patients had poor result.

FIGURE 27. RESULTS OF SURGICALLY MANAGED FRACTURE CALCANEUM

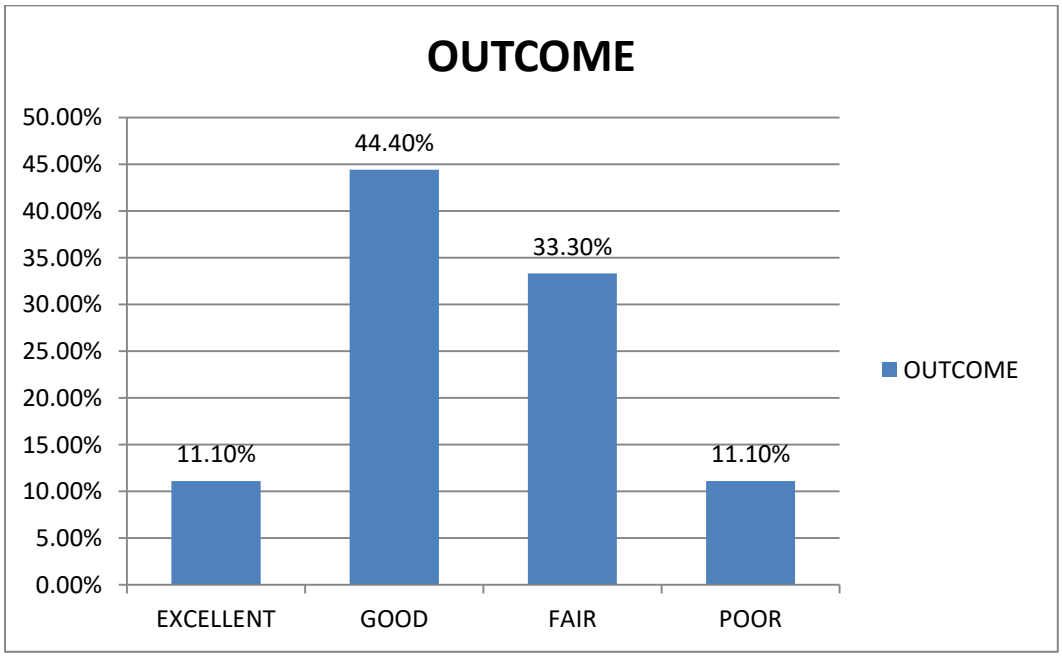


TABLE 28. CORRELATION BETWEEN BOHLER'S ANGLE AND OUTCOME OF FRACTURE CALCANEUM

BOHLER'S ANGLE	EXCELLENT		GOOD		FAIR		POOR	
Decrease (n=2)	0	0.0%	0	0.0%	0	0.0%	2	100.0%
Increased (n=16)	2	12.5%	8	50.0%	6	37.5%	0	0.0%

From the above table it can be depicted that the increase in Bohler's angle post operatively was associated with better outcome while decrease in Bohler's angle post operatively was associated with poor outcome.

FIGURE 28. CORRELATION BETWEEN BOHLER'S ANGLE AND OUTCOME OF FRACTURE CALCANEUM

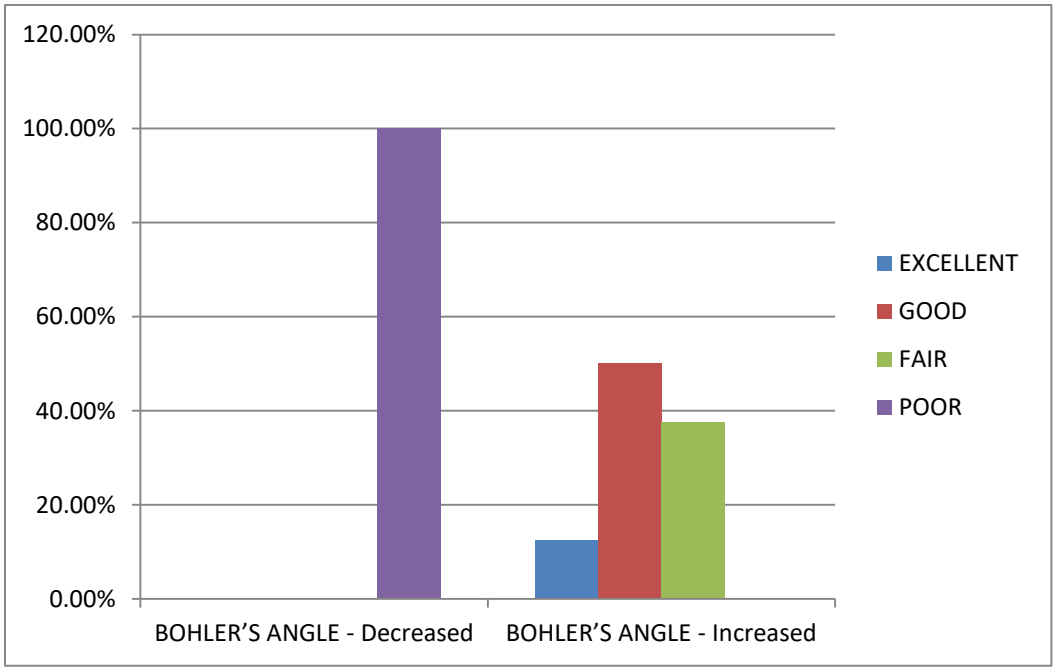
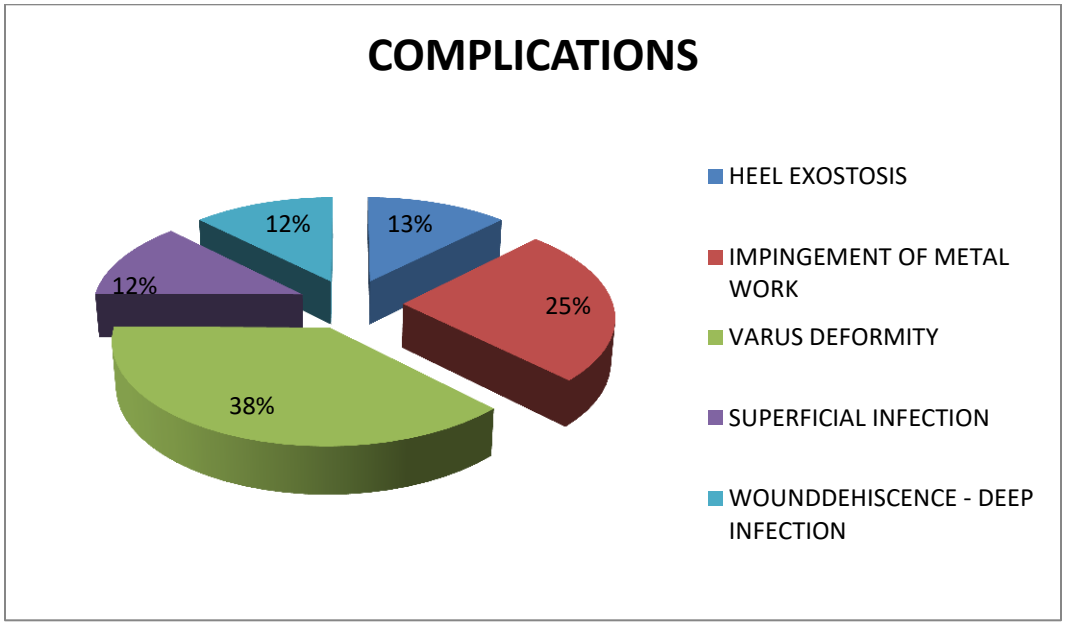


TABLE 29. SHOWS THE COMPLICATIONS OF SURGICALLY MANAGED FRACTURE CALCANEUM.

COMPLICATIONS	No. of cases	Percentage
HEEL EXOSTOSIS	1	5.5%
IMPINGEMENT OF METAL WORK	2	11.1%
SUPERFICIAL INFECTION	1	5.5%
WOUNDDEHISCENCE – DEEP INFECTION	1	5.5%
VARUS DEFORMITY	3	16.6%

In this study, it was observed that superficial infection, deep infection, heel exostosis was present in one case each while impingement of metal work was present in 2 cases and varus deformity was present in 3 patients .There was overlap of complications in 1 patients i.e. varus deformity and Superficial wound infection was present in same patient .

FIGURE 29. SHOWS THE COMPLICATIONS OF SURGICALLY MANAGED FRACTURE CALCANEUM.



DISCUSSION

Calcaneum is the most commonly fractured tarsal bone .Calcaneum account for 60% of all tarsal bone fracture .Prognosis of calcaneum fracture, as far as extra articular fracture are concerned ,is uniformaly good but for I/A calcaneum fractures the prognosis varies .Even the management of I/A fracture is controversial. Many treatment protocols has been advised in the past but there is no consenses for treatment that offers best results.

Historic cohort studies have shown that the clinical outcome of both operative and conservative treatment of intra articular calcaneum fracture is equal. [84,77] Recent studies have shown that the operative management of calcaneum fracture has no advantage [79, 91] while many of the other studies suggested that the superior results are obtained with surgical intervention [44,31,92] Confusion continues even in the recent literature ,which cities the advantages of one form of treatment over the other . Complications are present in both, conservative and surgically managed patients. Conservative treatment is associated with complications like subtalar joint pain, heel varus and tendon impingement where as surgical treatment is associated with complications like wound infection, skin flap necrosis, nerve injury, malunion etc. The present study was undertaken to know whether, with the better understanding of fracture pattern , advances in anaesthesia, prophylactic antibiotics, advances in imaging modalities like CT scan the results with surgical intervention in calcaneum fracture has improved or not .

In our present study, total of 18 patients were taken who had calcaneum fracture and were managed with surgical intervention (open reduction and internal fixation). 88.8% were male patients and 11.2% were female patients. All were between the age of 18 yrs to 75 years. Mean age in our study was 37.4 years. One of the main reason behind calcaneum fracture being common in 30 to 45 years of age group is that this age group is mostly working age group and calcaneum fracture mostly occurs

in patients who had history of fall from height, like fall while working at construction site or working at height. Bilateral involvement was seen in 33.3% of patients and remaining 66.7% patients have unilateral involvement .Out of unilateral cases 33.3% have left side involvement and 66.6% have right side involvement. Apart from the bilateral calcaneum fracture cases which is more in our study rest of the profile of our study matches with the study conducted by M chandramurthy et al. [93] in which 92% were male and 8% were female patients . All patients were between the age group of 18-60 years. Mean age was 37 years. Bilateral involvement was seen in 8 % of patients and rest of the 92% patients had unilateral involvement .Another study conducted by ashok vardhan reddy [1] also has 91.6% male patients and 8.3% female patients. All the patients were between the age group of 21 -58 years. The mean age was 38 years. Bilateral involvement was seen in 8.3 % patients. Out of unilateral cases, 63.6% patients had left side involvement and 36.4% patients had right side involvement.

TABLE-30 SHOWING THE MEAN AGE OF PATIENTS IN DIFFERENT STUDIES

Study	Male patients (%)	Female patients (%)	Mean age(yrs) of patients
Duymus et al [94]	87.5%	12.5%	42.7 yrs
M Chandramurthy et al [93]	92%	8%	37 yrs
Reddy et al [1]	91.6%	8.3%	38 yrs
Our study	88.8%	11.2%	36.8 yrs

From above discussion, we can say that majority of calcaneum fracture occurs in middle age [30-45] population.

In our study, the most common mode of injury was fall from height (88.88%), Followed by RSA (11.12%). Fall from height was the most common mode of injury because most of the patients were male construction workers .The profile of our study matches with the study

conducted by ashok vardhan reddy et al[1] in which the most common mode of injury was fall from height (79.16%) followed by RSA (20.84%) . Similarly studies conducted by M.J. Mitchell et al.[95], Nimmagadda et al[85], krishnaraj v et al[3], also shows that fall from height as the most common mode of injury

TABLE-31 SHOWING THE MOST COMMON MODE OF INJURY IN DIFFERENT STUDIES.

STUDY	YEAR	MOST COMMON MODE OF INJURY
M.J. Mitchell[95]	2009	Fall from height (71.5%)
Nimmagadda et al [85]	2014	Fall from height (100%)
Jacob R. Worsham[96]	2015	Motor vehicle accidents (54.6%)
Reddy et al [1]	2015	Fall from height 79.16%
krishnaraj v et al [3]	2018	Fall from height (92.7%)
Our study	2022	Fall from height 88.88%

In our study , 33.3% of the patients with calcaneum fracture had associated spine injury while 38.8% had other associated orthopaedic injury (like distal end radius fracture , distal tibia ,acetabulum fracture etc). Majority of patients in our study had fall from height as the mode of injury and as spine injuries are also common in fall from height patients. Therefore all patients were evaluated for spine injury and it was found that 33.3% patients in our study had associated spine injury. In a similar study conducted by D. A. O'Farrell et al[85] in which out of total cases, 12.5% cases had calcaneum fracture associated with spine injury while 33.3% patients had other associated injury (like contralateral ankle 3; hip 1; tibial

1; wrist 1; pelvic 2). Another study conducted by V krishnaraj v et al [3] in which out of total 72 patients 30.55% had spine injury associated with calcaneum fracture while 15.27% patients had other associated orthopaedic injury (like 5 pelvis , 5 opposite leg , 1 upper limb)

TABLE-32 SHOWING THE ASSOCIATION OF CALCANEUM FRACTURES WITH SPINE INJURY IN DIFFERENT STUDIES

Study	Year	Association with spine injury
D. A. O'Farrell et al [85]	1993	12.5%
Worsham et al [96]	2015	14.5%
krishnaraj v et al [3]	2018	30.55%
Our study	2022	33.3%

The results of our study matches with the results of studies conducted by the V krishnaraj v et al.[3], D. A. O'Farrell et al. [85] and Worsham et al. [96].

In our study, average number of days after which surgery was done is 17.28 days. All patients were operated only after the wrinkle sign become positive. Out of 18 patients, 4 patients were operated in 1st week, 4 patients were operated in 2nd week, 5 patients were operated in 3rd week and remaining 5 patients were operated after 3 weeks of injury. Out of 5 patients who were operated after 3 weeks of injury, 3 patients had COVID 19 due to which their surgery was postponed. From late operated cases 2 patients develop wound complications (1 wound dehiscence, 1 superficial infection) . The studies conducted by koski [86], Barthel et al [97], Jun Su, [98], Tennent [99] also shows that > 3 weeks delay in surgery from time of injury was associated with increased rate of wound complications. With increase in delay of the operative intervention there is formation of fibrosis and consolidation of fracture occurs this makes the fracture fragments difficult to separate and reduce. Moreover the soft tissues may also contract which makes the closure of the surgical wound more difficult when the calcaneal height is restored, thereby increasing the risk of wound healing problems and infection.[100] Therefore the ideal time to

perform surgery is 2nd to 3rd week because in majority of the cases wrinkle sign appears within 10-12 days of initial injury.

In our study the average union time is 12 weeks. Out of 18 patients, 10 patients had union of fracture with in or equal to 11 weeks, while 7 had union of fracture with in 11-14 weeks. while 1 out of 18 patients had delayed union in our study. A similar study conducted by reddy et al[1] which shows that the mean duration of radiological union was 13.38 weeks .Another similar study was conducted by abd Elfattah AA et al[101] which shows that the mean duration to achieve union was 9.65 weeks.

TABLE-33 SHOWING THE AVERAGE UNION TIME IN DIFFERENT STUDIES .

Study	Year	Average Union time (Weeks)
Reddy et al [1]	2015	13.38
Abd Elfattah AA et al [101]	2021	9.65
Georgekutty et al [102]	2020	12
Our study	2022	12

The results of our study are comparable with the studies of reddy et al[1], abd elfattah AA etal [101], and Geogekutty et al[102].

In our study , it was found that the pre operative mean value of Bohler's angle and Gissane's angle is 7.3 and 129.4 respectively while the post operative mean value of Bohler's angle and Gissnae's angle was 21.3 and 122.6 respectively . It was also observed that the patients in which bohler's angle increases and Gissane's angle decreases post operatively or in patients in which Bohler's angle increases and gets restored to normal [20-40] the results in those cases were excellent or good while in patients where Bohler 's angle does not increase significantly and only Gisaane's angle decreases post operatively in thoses cases the results were fair or poor. The results of our study are comparable with the studies conducted by redddy et al[1], nimmagadda et al[85] and patil et al

[103] which shows that there was a significant correlation between Bohler's angle and AOFAS score . A highly significant (**p<0.001**) increase in Bohler's angle was observed in the present study which signify that Bohler's angle was important in deciding the outcome of the fracture. In cases where Bohler's angle improved and gets restored to normal range post operatively better outcomes can be obtained.

TABLE-34 SHOWING THE MEAN PRE-OP AND MEAN POST-OP BOHLER'S AND GISSANE'S ANGLE IN DIFFERENT STUDIES

Study	Mean Pre op Bohler's angle	Mean Post op Bohler's angle	Mean Pre op Gissane's angle	Mean Post op Gissane's angle
Reddy et al [1]	11.76	26.30	126.9	119.76
Dr nimmagadda et al [85]	15	30	-	110
Patil et al [103]	-	24.6	-	120
Our study	7.3	21.3	129.4	122.6

In our study, the mean ROM at ankle joint was 31.16 degree in which mean dorsiflexion was 11.11 degree and mean plantarflexion was 20.05 degree. The mean ROM at subtalar joint was 24.93 degree in which the mean inversion was 15.88 degree and mean eversion was 9.05 degree.

Similar study conducted by M chandranmuethy et al [93] shows mean ROM at ankle joint was 39.9 degree out of which 21.6 degree was dorsiflexion and 18.33 degree plantarflexion. while the mean ROM at subtalar joint was 28.8 degree in which the mean inversion was 16 degree and mean eversion was 12.8 degree. Another study conducted by reddy et al [1] shows mean ROM at ankle joint was 45.15 degree out of which 24.7 degree was dorsiflexion and 20.45 degree plantarflexion. While the mean ROM at subtalar joint was 32.84 degree in which the mean inversion was 17.61 degree and mean eversion was 15.23 degree. It has been observed

that the mean plantarflexion, mean inversion and mean eversion of our study was comparable with the studies conducted by Reddy et al [1], Chandramuthy et al [93] ,GeorgeKutty[102] while mean dorsiflexion was not comparable with these studies.

TABLE-35 SHOWING THE MEAN DORSIFLEXION ,MEAN PLANTARFLEXION ,MEAN INVERSION AND MEAN EVERSION IN DIFFERENT STUDIES.

Study	Mean Dorsiflexion (degree)	Mean Plantarflexion (degree)	Mean inversion (degree)	Mean eversion (degree)
Reddy et al [1]	24.7	20.45	17.61	15.23
Chandramuthy et al [93]	21.6	18.33	16	12.8
GeorgeKutty et al [102]	21.6	18.33	15.9	12.16
Our study	11.11	20.5	15.88	9.05

In our study , it was observed that out of total patients , 16.7 % patients had varus deformity (type 3 stephen and sanders classification) [104] .These 16.7 % were those patients who were operated late, that is after a gap of 3 weeks from day of injury. Another studies conducted by V krishnaraj et al[3] and Abd elfattah AA et al [101] also had varus deformity in 4.16 % and 5% cases respectively only. Our study is in contrast to these studies as our study had varus deformity in 16.7% of cases which may be due to prolonged delay in surgery in these patients because delay in surgery causes early consolidation of fracture and due to which the varus of the heel becomes difficult to correct.

In our study, out of total 18 patients bone substitute was used in 4 patients. The patients in which bone substitute was used full weight bearing time was lower as compared to the patients in which bone

substitute was not used. No significant difference was found in these 4 bone substitute patients when compared with other 14 patients in term of reduction, AOFAS score, union time, healing time, post operative complications. Our study results were comparable with studies conducted by yang et al in 2012 [105], Duymus et al[94] and by Vinay et al[88] in 2013 which shows the similar results . Although no significant difference has been found in cases where bone substitutes were used as compared to cases where no bone substitute was used but we still recommend the use of bone substitutes, where feasible, as it allows the early weight bearing in calcaneum fracture patients.

In our study, according to American orthopaedic foot ankle society (AOFAS) ankle hind foot score . Out of total 18 patients, 2 had excellent outcome (11.1%, 8 had good outcome (44.4%), 6 had fair outcome(33.3%), and 2 patients had poor outcome (11.1%). Due to the good reduction and restoration of Bolher's angle 55.6 % of the Patients had good or excellent result .while inability to restore Bohler's angle and grade IV (Sander's) fracture patients had fair or poor.

Using similar scoring (AOFAS) system reddy et al [1] conducted a study which shows that out of total 26 fractures, 5 had excellent outcome (19.23%), 15 had good results(57.69%) , 4 had fair outcome(15.38%) and 2 had poor outcome(7.69%). Another similar study conducted by chandramurthy et al [93] shows that after using AOFAS scoring system for evaluating the outcome of surgical management of calcaneum fracture it was found that out of 26 cases, 16 had good results (61.5%), 7 had fair results [26.92] and 2 had poor results(7.69%) .

TABLE-36 SHOWING THE RESULTS OF DIFFERENT STUDIES

Study	Year	Excellent result	Good results	Fair results	Poor results
Georgekutty et al (n-50)[102]	2020	-	32(64%)	14(28%)	4(8%)
Reddy et al [1]	2015	5(19.23%)	15(57.69%)	4(15.38%)	2(7.69%)
Chandramurthy et al [93]		-	16(61.5%)	7(26.92%)	2(7.69%)
V krishnaraj et al [3]	2018	23.6%	45.8%	23.6%	6.9%
Our study (n-18)	2022	2(11.1%)	8(44.4%)	6(33.3%)	2(11.1%)

Therefore the results of our study were comparable with the other similar studies.

In our study, the following **complications** were present :-

- Heel exostosis - 1
- Superficial infection- 1
- Wound dehiscence -1
- Implant impingement-2
- Varus deformity -3

Various risk factors for post operative wound complication of calcaneum fracture after plating described by ding MD et al [83] are smoking, diabetes mellitus, Sanders type, number of residents and/or fellows during the case, duration of surgery, estimated blood loss, and high number of persons present in the operating room during the entire case as potential independent risk factors for postoperative wound complication in closed calcaneal fractures managed surgically.(ORIF)

In our study, superficial wound infection was present in one patient and that patient was a smoker too. It may be possible that due to vasoconstrictor action of nicotine, it reduces the blood flow to the skin which causes tissue ischaemia and delayed wound healing. Also the

nicotine increases the platelet adhesiveness. Therefore it increases the risk of microvascular occlusion that leads to further ischaemia. [83] The patient was managed conservatively with i/v antibiotics and daily local wound care.

In our study, wound dehiscence was present in one diabetic patient. It has been seen that diabetes can impede wound healing and predispose patients to infection through ischemia secondary to microvascular abnormality. Retrospectively when the records of this patient was investigated it was found that the HBA1C of the patient was higher than 7. Therefore we can conclude that Strict diabetic control before and after the surgical intervention is necessary in decreasing the risk of wound complications. In our study this patient was managed with i/v antibiotics and daily wound care but that too failed and after that patient was taken up for surgery and implant removal was done after which wound healed.

In our study, heel exostosis was present in one patient. The most common cause of pain in heel exostosis is the formation of bony prominence, due to the planter displacement of fracture fragment after initial injury and the union of fracture fragment in same position which leads to localized tenderness over the planter surface of calcaneum [59].The patient was given heel pads to relieve the pressure .

In our study, implant impingement was present in 2 patients. It may be due to the poor soft tissue coverage of the implant. In the recent times due to the availability of modern implants the rate of implant impingement (low profile plates) has decreased.

Varus defromity was present in 3 patients in our study and all the 3 patients where operated after 3 weeks of intial trauma. It may be possible that due to prolonged delay in surgery in these patients, early consolidation of fracture occurs and due to which the varus of the heel becomes difficult to correct.

Similar study conducted by krishnaraj et al [3] in which out 72 operated cases 18 paients had complications . (infection -3, wound healing problem -3, varus deformity -3, implant prominence -4 , stiffness-5)

From our study it can be suggested that smoking, DM-II, soft tissue damage and type of fracture (Sander's) are the important risk factors associated with complication after operative management of calcaneum fracture

From the above discussion about complications it can be concluded that:-

- Diabetes and smoking continues to be the risk factors for the wound related complications.
- Rate of implant impingement has decreased recently due to the availability of modern implants (low profile plates)
- Waiting for the wrinkle sign to become positive before surgery has been associated with decreased wound related complications
- The rate of heel exostosis has decreased in our study mainly because, intraoperatively more stress has been given on restoring the bohler's angle

SUMMARY & CONCLUSION

- Calcaneum fracture were more common in males as compared to females. (m:f = 8:1)
- Most common mode of calcaneum fracture was fall from height
- Bilateral involvement of calcaneum fracture was 33.3%, in our study.
- Association of spine injury with calcaneum fracture was 33.3% whereas association with other orthopaedic injury 38.8%
- Average number of days after which surgery was done is 17.28 days
- Average union time was 12 weeks and only one patient in our study had delayed union .
- For classificaton of the fractures sander's classification was used . Out of 18 cases , 10 cases were type iii , 6 were type ii and 2 were type iv .
- Average pre operative and post operative bohler's angle was 7.3 degree and 21.3 degree respectively.
- In cases where bohler's angle gets restored between 20-40 degree post operatively ,had excellent or good results .
- The average rom at ankle joint was dorsiflexion:- 11.11 degree and plantarflexion :- 20.05 degree
- The average rom at subtalr joint was inversion:- 15.8 degree and eversion :- 9.05 degree
- Bone substitues was used in 4 patients in our study. Although full weight bearing time was lower in these patients but no significant differnce was found in these patients as compared to rest of the other patients in terms of reduction , aofas score ,union time , healing time , post operative complications .
- in our study 2 patients had excellent results , 8 had good results, 6 had fair and 2 had poor results

- Various complications were implant impingement , superficial wound infection , heel exostosis , wound dehiscence and varus deformity

CONCLUSION

1. Majority of the calcaneum fractures occurs in the middle aged population So this has to be dealt properly so that good results can be obtained
2. The most common mode of injury in calcaneum fracture is fall from the height.
3. Patient with calcaneum fracture should be evaluated for spine injury as it is the commonly associated injury in calcaneum fracture.
4. Best time to operate for calcaneum fracture is between 7 -14 days, after wrinkle sign become positive .
5. Intra operatively more stress should be given to restore the bohler's angle to improve the outcome
6. Bone grafting or bone substitutes should be used whenever feasible as it allows the early weight bearing
7. Diabetes and smoking are the important risk factors associated with wound related complications.

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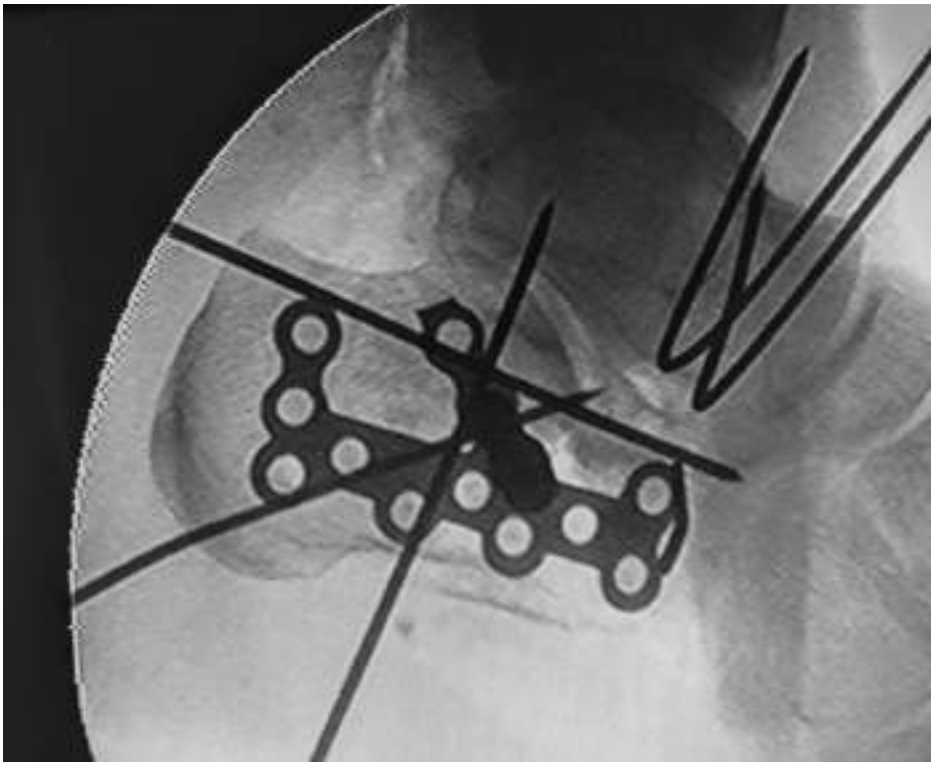
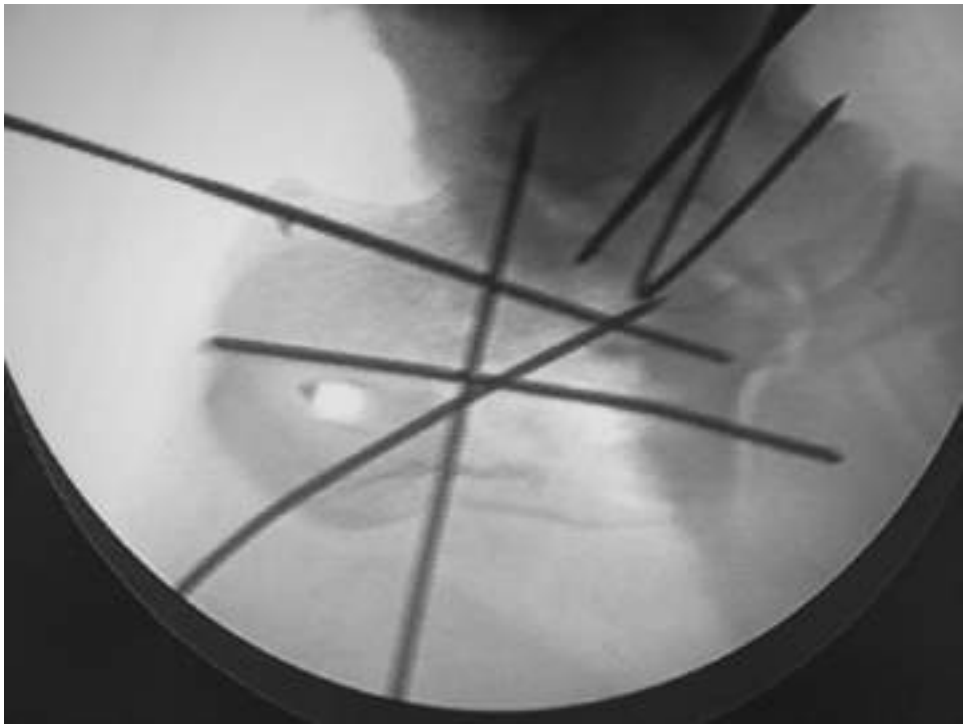
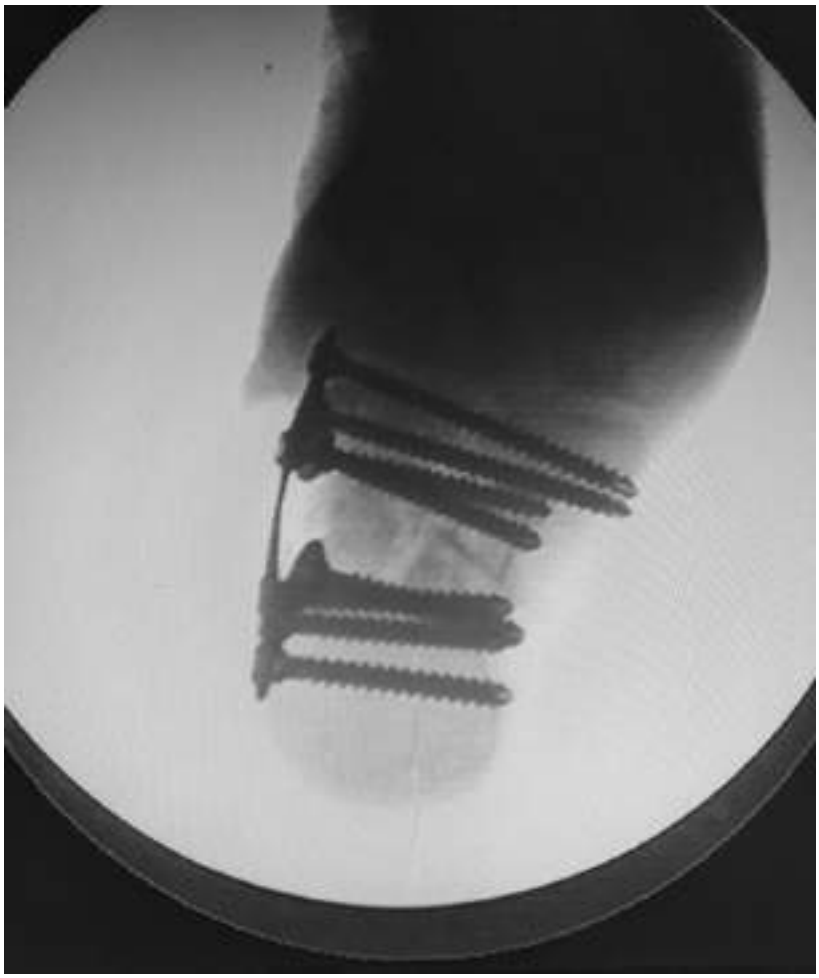
INTRAOPERATIVE IMAGES



INTRAOPERATIVE IMAGES





CASE 1: PRE-OPERATIVE XRAY

POST-OPERATIVE X-RAY AFTER SURGERY (DAY 1)

POST-OPERATIVE X-RAY AFTER SURGERY (6 MONTHS)

CASE-2 PEROPERATIVE X-RAY

POSTOPERATIVE X-RAY

POSTOPERATIVE X-RAY

CASE -3 PREOPERATIVE X-RAY

POSTOPERATIVE X-RAY

WOUND DEHISCENCE (DAY 20)

AFTER IMPLANT REMOVAL

RANGE OF MOTION

Sr. No.	MRD NO.	NAME	Age	Sex	Mode of injury	DOI	DOS	NO. OF DAYS AFTER WHICH SURGERY DONE	SIDE OPERATED	ASSOCIATION WITH SPINE INJURY Y/N	BILATERAL CALCANEUM INVOLVEMENT A- ABSENT, P -PRESENT	Past H/O	Personal H/O		CT Classifications	Dorsiflexion	Plantar flexion	Eversion	inversion
													SMOKING	ALCOHOL					
1	328317	GJ	40 YRS	M	FALL FROM HEIGHT	24/07/2017	18/8/2017	24DAYS	LEFT	N	A	HTN	N	N	III	10	20	10	15
2	385839	G	32 YRS	M	FALL FROM HEIGHT	10/11/2017	18/11/2017	7DAYS	RIGHT	N	A	NIL	N	N	II	15	30	13	25
3	430093	A	24YRS	M	FALL FROM HEIGHT	31/01/2018	12/2/2018	11DAYS	LEFT	N	P	NIL	Y	Y	II	17	25	10	20
4	607961	SB	36 YRS	M	FALL FROM HEIGHT	10/10/2018	25/10/2018	14DAYS	LEFT	N	P	HTN	N	Y	III	5	15	5	10
5	660283	KK	48 YRS	F	FALL FROM HEIGHT	27/01/2019	5/2/2019	8DAYS	RIGHT	Y	A	NIL	N	N	III	15	30	15	25
6	709505	VK	60YRS	M	FALL FROM HEIGHT	16/04/2019	2/5/2019	15DAYS	RIGHT	N	A	HTN +	Y	Y	III	12	25	13	23
7	747402	JS	30YRS	M	FALL FROM HEIGHT	9/7/2019	30/07/2019	20DAYS	LEFT	N	A	NIL	N	Y	III	8	13	5	10
8	795066	GS	37YRS	M	RSA	25/08/2019	31/08/2019	5 DAYS	LEFT.	Y	A	HTN	N	N	II	13	28	12	28
9	787624	HK	59 YRS	F	FALL FROM HEIGHT	16/08/2019	9/9/2019	23DAYS	RIGHT	Y	A	DM+	N	N	III	5	10	5	8
10	839434	B	39 YRS	M	FALL FROM HEIGHT	29/10/2019	5/11/2019	6 DAYS	RIGHT	Y	A	NIL	N	Y	III	17	25	16	20
11	880303	A	29YRS	M	FALL FROM HEIGHT	18/01/2020	25/01/2020	6DAYS	RIGHT	N	P	NIL	N	Y	II	10	20	8	5
12	936310	S	51 yrs	M	FALL FROM HEIGHT	20/06/2020	24/07/2020	34DAYS	LEFT	Y	P	NIL	Y	N	IV	10	10	0	0
13	940764	PM	27YRS	M	FALL FROM HEIGHT	6/7/2020	23/07/2020	16DAYS	RIGHT	Y	A	NIL	N	N	III	10	15	8	12
14	952241	MM	31YRS	M	FALL FROM HEIGHT	7/8/2020	28/8/2020	20DAYS	LEFT	N	A	NIL	Y	Y	II	5	10	5	8
15	961212	SK	25YRS	M	FALL FROM HEIGHT	1/9/2020	17/10/2020	46DAYS	RIGHT	N	P	NIL	N	N	III	8	15	5	10
16	986184	LS	19 YRS	M	RSA	25/10/2020	12/11/2020	17 DAYS	RIGHT	N	A	NIL	N	N	II	15	25	15	25
17	1084611	R	34YRS	M	FALL FROM HEIGHT	19/02/2021	15/03/2021	26DAYS	LEFT	N	A	NIL	N	N	III	10	25	8	22
18	947026	S	42 YRS	M	FALL FROM HEIGHT	24/07/2020	7/8/2020	13 DAYS	RIGHT	N	P	NIL	N	Y	III	15	20	10	20

Sr. No.	MRD NO.	Xrays				UNION TIME (In Weeks)	AOFAS SCORE											COMPLICATIONS
							PAIN	FUNCTION (50 POINTS)	MAXIMUM WALKING DISTANCE	WALKING SURFACES	GAIT ABNORMALITY	SAGGITAL MOTION (FLEXION PLUS EXTENSION)	HIND FOOT MOTION (INVERSION PLUS EVERSION)	ANKLE HINDFOOT STABILITY (ANTEROPOSTERIOR, VARUS-VALGUS)	ALIGNMENT (10 POINTS)	FINAL SCORING	OUTCOME	
		Calcaneum-Axial view/Lateral view					6MONTHS	6MONTHS	6MONTHS	6MONTHS	6MONTHS	6MONTHS	6MONTHS	6MONTHS	6MONTHS	6MONTHS	6MONTHS	
		Bohler's Angle		Gissane Angle														
		Pre Op	Post Op	Pre Op	Post Op													
1	328317	6	22	130	127	11	30	7	2	3	8	8	3	8	10	79	GOOD	NIL
2	385839	8	24	125	132	13	30	7	2	3	8	8	3	8	10	79	GOOD	NIL
3	430093	10	25	118	112	10	30	7	4	3	8	8	3	8	10	81	GOOD	NIL
4	607961	-10	14	150	126	9	20	7	2	3	8	4	3	8	10	65	FAIR	IMPLANT IMPINGEMENT
5	660283	12	33	112	118	11	30	7	4	3	8	8	3	8	10	81	GOOD	NIL
6	709505	17	25	110	120	12	30	10	4	3	8	8	3	8	10	84	GOOD	NIL
7	747402	-8	18	140	122	11	30	7	2	3	8	4	3	8	10	75	GOOD	HEEL EXOSTOSIS
8	795066	4	17	145	118	13	30	7	2	3	8	8	3	8	5	74	FAIR	NIL
9	787624	12	13	130	115	22	30	4	2	0	8	4	0	8	10	66	FAIR	WOUND DEHISCENE- DWI
10	839434	10	26	102	118	10	40	7	4	5	8	8	3	8	10	93	EXCELLENT	NIL
11	880303	12	32	140	135	14	30	7	4	0	8	8	0	8	10	75	GOOD	NIL
12	936310	10	6	155	117	12	30	4	2	3	4	4	0	0	5	52	POOR	SWI,VARUS DEFORMITY
13	940764	20	26	137	132	11	30	7	2	3	8	4	3	8	10	75	GOOD	NIL
14	952241	15	12	130	120	13	20	4	2	0	4	4	0	8	10	52	POOR	IMPLANT IMPINGEMENT
15	961212	14	17	112	124	10	30	7	2	3	8	4	3	0	10	67	FAIR	VARUS DEFORMITY
16	986184	16	34	120	125	11	40	10	2	5	8	8	3	8	10	94	EXCELLENT	NIL
17	1084611	3	22	150	128	12	30	4	2	3	8	8	3	0	5	63	FAIR	VARUS DEFORMITY
18	947026	12	18	124	118	11	20	7	2	3	4	8	3	8	10	65	FAIR	NIL

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Date 21/4/2021

The Principal,
DMC Ludhiana

Subject: **Approval of Plan of Thesis.**

This is to inform you that the Faculty of Medical Sciences in its meeting held on 22.01.2021 has approved the plan of thesis of **Dr. Ramandeep**, a student of your college for **MS Orthopaedics** along with the names of Supervisor/Co-Supervisor as under:-

Topic Plan of Thesis
To study the union rates and complications associated with surgically managed fracture calcaneum

Supervisor
Dr. Rajnish Garg
Prof. & Head,
Dept. of Orthopaedics,
DMCH, Ludhiana.

Co-Supervisor
Dr. Shekhar Singal
Assoc. Prof.,
Dept. of Orthopaedics,
DMCH, Ludhiana.

The student has to submit the three copies of thesis (along with PDF format) , to the Controller of Examinations, BFUHS, Faridkot, at least six months before the commencement of theory examination, if he/she is otherwise eligible to take the examination. He /She must directed to attach a photocopy of this letter with the forwarding letter while submitting thesis to the University along with the letter of approval of University for change of supervisor/Co-Supervisor, change of topic,(if any).

S P Singh

Dr. S P Singh MS(Oph)
Controller of Examinations

Note :

1. ***If any discrepancy found regarding topic of thesis or Supervisor/Co-Supervisor, inform undersigned within one month after issue of this letter.***
2. *The student may submit the thesis as per the schedule already conveyed i.e for May/June examination 30th Nov of the preceding the year of examination and for Nov/Dec examinations 31st May of the year of examination.*

TO STUDY THE UNION RATES AND COMPLICATIONS ASSOCIATED WITH SURGICALLY MANAGED FRACTURE CALCANEUM

THESIS PROPOSAL

FOR APPROVAL OF SUBJECT OF THESIS TO BE SUBMITTED

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF SURGERY

In

ORTHOPAEDICS

OF THE

BABA FARID UNIVERSITY OF HEALTH SCIENCES

FARIDKOT

NOVEMBER, 2019

DR. RAMANDEEP

DEPARTMENT OF ORTHOPAEDICS
DAYANAND MEDICAL COLLEGE & HOSPITAL, LUDHIANA
LUDHIANA, PUNJAB-141001

ABSTRACT OF PLAN OF THESIS

Title	TO STUDY THE UNION RATES AND COMPLICATIONS ASSOCIATED WITH SURGICALLY MANAGED FRACTURE CALCANEUM
For the degree of	M.S. Orthopaedics
Name of the candidate	Dr Ramandeep
Supervisor	Dr. Rajnish Garg, Professor & Head, Department of Orthopaedics, DMCH, Ludhiana
Co-supervisor	Dr. Shekhar Singal, Associate Professor, Department of Orthopaedics, DMCH, Ludhiana
Institution	Dayanand Medical College and Hospital, Ludhiana
University	Baba Farid University of Health Sciences, Faridkot

Introduction: Fractures of Calcaneum are the most common of all tarsal fractures. The treatment of displaced intra-articular fractures is controversial. Earlier, most of the fractures were treated conservatively in plaster cast. These days some surgeons are operating the fractures of calcaneum with improved surgical techniques.

Aim of study: The purpose of this study is to study the union rates and complications associated with surgically managed fracture calcaneum on the basis of subjective, clinical and radiological criteria in our hospital.

Material and methods: The study will includes patients who will be between 18-60 years of age. A sample of patients will be selected. A complete history of patients will be obtained along with a thorough clinical examination will be done. The fractures in our study will be the closed calcaneum fractures. Sander's classification will be used to classify the fracture. The patient will then be posted for open reduction internal fixation. Follow up will be done to evaluate union rates and complications associated with surgically managed fracture calcanum by clinically and radiologically examination at 1 month 3 month, 6 months.

Clinical Significance: The study will show union rates and complications associated with surgically managed fracture calcaneum. Various complications and their incidence would also be assessed. The study will act as a benchmark to set up guidelines for management of fracture calcaneum.

Keywords: Fracture Calcaneum

(Signature) Candidate

(Signature) Co-supervisor

(Signature) Supervisor

(Signature) Principal

CERTIFICATE OF FACILITIES AVAILABLE

This is to certify that the facilities for work on the subject of thesis titled **"TO STUDY THE UNION RATES AND COMPLICATIONS ASSOCIATED WITH SURGICALLY MANAGED FRACTURE CALCANEUM"** exist in the Department of Orthopaedics at Dayanand Medical College and Hospital, Ludhiana and will be provided to the candidate. We will see that the data being included in the thesis are genuine and is collected by the candidate himself under our supervision and guidance.

Supervisor

Dr. Rajnish Garg
Professor & Head
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Co-Supervisor

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Associate Professor
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Dr. Rajnish Garg
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Place: _____

Date: _____

APPROVAL PROFORMA
BY
RESEARCH & ETHICAL COMMITTEE
DAYANAND MEDICAL COLLEGE & HOSPITAL, LUDHIANA

Name of candidate	Dr. Ramandeep
Department	Orthopaedics
Topic of Thesis	TO STUDY THE UNION RATES AND COMPLICATIONS ASSOCIATED WITH SURGICALLY MANAGED FRACTURE CALCANEUM
Likely date of appearing in PG examination	MAY 2022
Date of enrollment	MAY 13, 2018
Name of Head of Department	Dr. Rajnish Garg
1) Supervisor **2) Co-Supervisor**	Dr. Rajnish Garg Dr. Shekhar Singal
Signature of Members of Research Committee with Stamp	**Signature of Members of Ethics Committee with Stamp**
Dr. Jaspal Singh (Professor & Head, Surgery)	Mr. A K Jindal (Member, Ethics Committee)
Dr. Dinesh Gupta (Professor & Head, Medicine)	Dr. Anu Sharma (Professor, Anatomy)
Dr. Sandeep Kaushal (Assistant Dean Academics)	Dr. Deepinder K Chhina (Professor & Head, Microbiology)
Dr. Rajoo Singh Chhina (Dean Academics)	Dr. Neena Sood (Professor & Head, Pathology)
Dr. Gurpreet S Wander (Vice Principal)	Dr. Gurpreet S Wander (Vice Principal)
	Dr. Gagandeep Singh (Secretary, Ethics Committee Professor & Head, Neurology)

Approved: Yes / ~~No~~

Dr. Sandeep Puri
Chairperson
Research Committee

Chairperson
Research Committee

Approved: Yes / ~~No~~

Prof. Arvind Malhotra
Chairman
Ethics Committee

Chairperson
Ethics Committee

BABA FARID UNIVERSITY OF HEALTH SCIENCES, FARIDKOT

PROFORMA FOR REGISTRATION OF SUBJECT FOR DISSERTATION

1	NAME OF THE CANDIDATE AND ADDRESS	DR. RAMANDEEP VISHKARMA NAGAR, TAJPUR ROAD LUDHIANA, PUNJAB
2	NAME OF THE INSTITUTE	DAYANAND MEDICAL COLLEGE & HOSPITAL, LUDHIANA
3	COURSE OF STUDY AND SUBJECT	M.S. Orthopaedics
4	DATE OF ADMISSION OF COURSE	13th MAY,2019
5	TITLE OF THE TOPIC	TO STUDY THE UNION RATES AND COMPLICATIONS ASSOCIATED WITH SURGICALLY MANAGED FRACTURE CALCANEUM

6. BRIEF RESUME OF THE INTENDED WORK

6.1 NEED FOR THE STUDY

Calcaneal fractures account for about 3% of all fractures. Most (70%) of them are intra articular. Calcaneal fractures accounting for 65% of tarsal injuries. It is the most commonly fractured tarsal bone. Fall from height especially in male constuction workers is the frequent cause. Most of these persons unfortunately are the sole earning members of the family. Hence this results in more finanacial burden apart from the significant morbidity for the patient

The suitable management of calcaneal fractures is unsettled. Tracing the method of treatment of these fractures is illustrated by period of aggressive surgical fixation of these fractures and later by a period of resorting to closed treatment methods. In between these two extremes there were times when carefully chosen fractures for surgery were found to give a reasonable results.

SURGICAL ANATOMY

Calcaneum as a bone forms a base or vertical support for body weight. It is the biggest of all tarsal bones with many articulations. It also functions as a lever arm powered by gastro-soleus. It also supports and conserves the length of lateral column of the foot.

Calcaneum has a thin cortical shell which encloses a mass of cancellous bone that remodels with various stresses applied to it. So it has been described being 'Egg like' i.e. hard on the outside and soft on the inside. Tuberosity is the most posterior aspect of the calcaneum; distal to the tuberosity, is the body of calcaneum.

The lateral view shows 2 angles on X-ray. Bohler's Angle (Tuber joint angle; is the complement of an angle produced by two lines. The first line is drawn between the highest point of anterior process connecting to the highest part of the posterior facet or articular surface. A similar line is drawn between the same points on the posterior facet connecting to the most superior point of the tuberosity of the calcaneum.

It usually measures between 25-40°. Loss of this angle on plain lateral radiographs means there is loss of calcaneal height.

Crucial angle of Gissane is an additional angle "formed by the downward portion of the posterior facet where it joins the upward portion. This angle faces the lateral process of the talus and is disturbed at the time of calcaneal fracture by axial compressive forces. The normal measure of the angle of Gissane is about 120-145°.

The two main regular types of calcaneal fractures are

(1) Joint depression type. Here the fragment is short; it extends only for a short distance behind the posterior facet.

(2) Tongue type. Here the fragment is long, and it extends to the posterior aspect of the calcaneal tuberosity.

CLASSIFICATIONS

There is a broad agreement that the degree of joint destruction at the time of injury decides the results of the calcaneal fracture management. Radiological information has limitations like the position of the limb during the radiography, lack of adherence or standardization of the radiographic procedure. There is no handy classification system. Thus the assessment of every calcaneal fracture and comparison of fracture patterns becomes difficult.

CLASSIFICATION OF INTRA ARTICULAR FRACTURES OF CALCANEUM

1. Classification based on plain radiographs - Essex Lopresti /Rowe et al/ Souer & Remy/Stephenson/Paley & Hall
2. Classification based on CT Scan - Crosby Fitzgibbons /Sanders/De Souza
3. Classification based on CT and plain X-ray - Orthopaedic Trauma Association

SANDER'S CLASSIFICATION

Type I All nondisplaced articular fractures (less than 2mm)

Type II Two-part fractures of the posterior facet

Type IIA,IIB,IIC Based on location of primary fracture line

Type III

Three-part fractures usually featuring a centrally depressed fragment

Types IIIAB, IIIAC, IIIBC Based on location of primary fracture line

Type IV Four part articular fracture

The management of fractures of calcaneus has undergone a sea of change from the initial use of supervised neglect to the use of complicated closed reduction devices.

A clear and targeted understanding of the goals aimed at after calcaneal fracture fixation is vital and a prerequisite for implant use. The ideal achievement in any intraaricular fracture are better anatomical articular reconstruction, maintenance of the articular surface, reconstitution of Bohler's and Gissane angle, less invasive faster surgery, minimal wound complications and early mobilization of the ankle.

Despite the contrary evidence favouring both modalities, today there is a gradual shift in the management of calcaneal fractures from conservative to surgical treatment. This is due to better understanding and clarity of patterns of fractures by radiological techniques like Computerised tomography .There is still confusion in the aspects of open reduction and internal fixation, approch and type of implant to be used.

One main reason for failure of surgical intervention is inappropriate implant or incision choice. Complications manifest commonly in the form of inadequate fixation and wound related problems

Implant decision is a complex issue. Its odd shape is the reason behind difficulty in application of implants. Regaining the Bohler's and Gissane angle and reconstruction of posterior facet are all the complex task. It is always accompanied with some soft tissue compromise.

There remains, however, no consensus regarding the surgical approach, with many having been described, including medial, lateral, combined medial and lateral, extended lateral and sinus tarsi approached.

So it is the need of the hour, to identify treatment techniques, which use lesser hardware, and provide better functional outcomes in terms of shorter duration of treatment, better stability and early weight bearing.

This study is being done to evaluate the results of operative management for intra-articular calcaneum fractures on basis of subjective, clinical and radiological criteria in our hospital setup.

6.2 REVIEW OF LITERATURE

Age old the treatment approach of calcaneum fracture had been only Careful neglect (ie conservative management) Because of total absence of diagnostic tools at that period of time

As the time progressed intend in the operative management of calcaneum gained momentum but it was charged by poor operative technique and limited understanding of anatomy of calcaneum

Cotton and wilson recommended (1908) that one should not do an Open reduction of a calcaneal fracture at all. The famous quote by Mclaughlin compared open reduction and fixation of a calcaneal fracture To "nailing of a custard pie to the wall".

Later in 1931 Bohler supported open reduction but still the main reasons for the dominance of non operative treatment were due to the practical problems not only connected specifically with operative treatment of calcaneum but also to other general problems like ineffective anesthesia, deficiency of good quality intraoperative radiography like fluoroscopy and the type of antibiotics at that period. Also the poor understanding of the principles of internal fixation leads to more complications.

Conn in 1935 found poor results with the standard treatment methods, recommended primary triple arthrodesis, in a delayed manner in this method he achieved exceptional results.

Discontented with either conservative or late surgical management of the calcaneal fractures, Palmer tried operative treatment of acute displaced intra articular calcaneal fractures using a standard lateral Kocher's approach. He reconstructed the joint by elevating the fracture fragment with bone graft and published his work in 1948. Later 1952, Essex Lopresti reported similar findings.

Not satisfied with the preliminary results of operative fixation some surgeons started advising primary subtalar arthrodesis, Dick and Harris began started using Gallie's technique of subtalar arthrodesis for malunited fractures of calcaneum as the treatment of choice, even for acute calcaneal fractures. They showed excellent results with patients

returning to work early. Following this many surgeons performed sub-talar arthrodesis for acute calcaneal fracture.

Even after all these in a long term follow up Lindsay and Daver, concluded that sub-talar arthrodesis was not only unnecessarly but also resulted in problems. They concluded that best results were got only with 15 conservative treatment of patients. As a result the operative treatment of acute calcaneal fractures once again went into disrepute. So only later, between 1960s and70s most workers advocacted of conservative management.

In the last 20 years, because of improved anesthesia, introduction of antibiotics principles of internal fixation and preoperative imaging CT and intra operative imaging intensifier have permitted surgeons to employ operative fixation for many intraarticular fracture, obtaining good results.

If the personality of fracture is not carefully studied and mode of fixation are not carefully selected and the basic principles of open reduction and internal fixation are not adhered to by the surgeon then results cannot be expected.

Maintenance of Bohler's angle is necessary for satisfactory results along with maintenance of articular congruence of posterior facet of calcaneum and crucial angle of Gissane. Open reduction and internal fixation with locking compressive plate in displaced intraarticular fracture calcaneum shows good outcome. Results are more favourable in less comminuted as compared to more comminuted.[1]

Controversies also exist with regards to primary bone grafting to prevent collapse. A series of cases have been reported with no significant collapse, even without using bone graft for calcaneal fixation, showing no specific benefit with use of the bone graft to prevent collapse.[2-4]

However, Leung et al [3], Thordarson et al[4], and Schildhauer et al[1] recommended use of bone graft or cement to increase stability and compressive strength of fixation and rapid rehabilitation. Zhongguo et

al[4] study reports bone graft in the surgical treatment of calcaneal fractures carries no advantage.

The surgical treatment of closed calcaneus fracture by open reduction and internal fixation (ORIF) has become widely accepted. The main objectives of the ORIF procedure are to achieve realignment of the posterior facet of the subtalar joint and to recover the height of the hindfoot. ORIF has substantial advantages over earlier techniques (such as closed reduction and pinning with the Steinmann pin, or the Essex-Lopersti technique), because it reduces and fixes the fracture, recovers the normal morphological structure and biomechanics of the foot, and prevents pain and stiffness of the subtalar joint by facilitating motion of the foot within 6 weeks postoperatively. In addition, ORIF decreases pain early in the postoperative period, partly due to the early mobilization that is possible following this procedure.

With techniques that do not involve percutaneous reduction, patients commonly experience more pain than they do with ORIF, due to the longer wound and deeper dissection that are necessary aspects ofother procedures.[5]

However Calcaneal surgery is infamous for its post-operative infection rate leading to prolonged hospital stay and secondary operations. The incidence of a wound infection following operative treatment of closed calcaneal fractures varies between 2 % and 25 % and rates of complications requiring surgery are up to 21 %.[6-11]

According to one study, Reported complications were ; - infection and skin flap necrosis, (13.6%), neurovascular injury (2.8%), post traumatic arthritis (1.2 %), malreduction / implant problems (0.8%), nonunion (0.1%).[13]

Some studies identified covariates associated with an increased risk of wound complications such as a higher body mass index (BMI), smoking [6,12] and drug abuse.[9] In addition, "the incidence of wound infections increased in patients who were managed as outpatients pre-

operatively or underwent surgery more than five or 14 days following trauma.[5,11]

DUE TO COMPLICATIONS ASSOCIATED WITH OPERATIVE MANAGEMENT STILL THE BEST WAY TO TREAT CALCANEUM FRACTURE IS IN DILEMMA

various complications of fracture calcaneum

Fracture Blisters and Swelling

Acute calcaneal fractures almost always are accompanied by considerable soft tissue swelling. The wrinkle test has been used to ascertain whether swelling has regressed enough to allow surgical intervention.[14]

Swelling may be complicated additionally by the occurrence of fracture blisters. Extensive blistering after injury presents as a relative contraindication to open reduction and may affect timing of surgery. Cases of wound infection after incisions made through blood-filled fracture blisters have been reported.[15,16]

Wound Infection

Wound problems are the most common complication of surgical treatment. They usually are classified by extent or depth as being superficial or deep, with the incidence of superficial infection ranging from 10% to 27%, and the incidence of deep infection ranging from 1.3% to 2.5%.[14]

Compartment Syndrome

Factors contributory to the development of compartment syndrome after calcaneal fractures include bleeding from cancellous bone fragments, anatomic soft tissue constraint by the plantar aponeurosis, and the crushing nature and high energy of the injury.

The incidence of acute compartment syndromes after calcaneal fractures has been reported to be 10% to more than 50%.[17-19]

Neurovascular Injury

Acute neurologic injury commonly occurs iatrogenically.

Tendon Impingement and Calcaneofibular Impingement

Injury to the various tendons crossing the ankle occurs in calcaneal fractures, and can be caused acutely by fracture edges spiking through the tendons, dislocation from their anatomic grooves, and entrapment of tendons between fracture fragments.

Heel Pad Pain and Heel Exostosis

Heel pad pain is the second most common site of pain after a calcaneal fracture.

Arthritis

Posttraumatic arthritis after intraarticular calcaneal fractures may affect the subtalar or calcaneocuboid joint.

Calcaneal osteomyelitis

Calcaneal osteomyelitis is one of the most difficult complications to treat.

6.3 AIMS AND OBJECTIVES OF THE STUDY

To analyse the union rates and complications associated with fracture calcaneum managed surgically.

7.0 MATERIAL AND METHODS

7.1 SOURCE OF DATA

The purpose of this study is to review and analyse the outcome of procedure. Study would be based on a retrospective and prospective review of the medical records of all cases of FRACTURE CALCANEUM who will or had undergo surgical management between 1st Jan 2017 and March 2021 at Dayanand Medical college Hospital, Ludhiana. .

Patients with fractures of calcaneum will be selected and treated with open reduction and internal fixation with locking compression plate/ screws depending upon surgeon "s choice .

All the patients will be evaluated with X-rays of the calcnaeum — axial, lateral and with CT scan.

In this study, we followed the Sander's classification to classify the fractures. Patients will be followed up at after 1 month , 3 months and 6 months by clinical examination, and final assessment will be made 6 months after surgery. In case of retrospective cases data will be taken from patients records.

METHOD OF COLLECTION OF DATA

Inclusion criteria:

1. All closed calcaneal fractures

Exclusion criteria:

1. Open fractures
2. Diabetic neuropathy
3. Peripheral vascular disease
4. Open calcaneal fracture part of crush injury

Study would be based on a retrospective and prospective review of the medical records of all cases of FRACTURE CALCANEUM who will or had undergo surgical management between 1 st January 2017 to march 2021 at Dayanand Medical college Hospital, Ludhiana.

Study requires the following investigations.

- The routine investigations required for surgery
- X-ray CALCANEUM AP & lateral view

- CT scan calcaneum

Before subjecting the patients for investigations and surgical procedures written/informed consent will be obtained from each patient/ legal guardian. All the investigations and surgical procedures will be undertaken under the direct guidance and supervision of the guide. Radiological investigations will be repeated post-operatively at 6 weeks, 12 weeks, 6 months intervals.

Duration of study:

- Prospective May 2019 to March 2021.
- Retrospective study January 2017 to April 2019.

Outcome: Outcome will be assessed using AOFAS SCORE.

STATISTICAL ANALYSIS:

Data will be described in terms of range; mean ±standard deviation (± SD), median, frequencies (number of cases) and relative frequencies (percentages) as appropriate. All statistical calculations will be done using SPSS (Statistical Package for the Social Science) SPSS 21 version statistical program for Microsoft Windows.

7.3 DOES THE STUDY REQUIRE ANY INVESTIGATIONS OR INTERVENTIONS TO BE CONDUCTED ON PATIENTS OR OTHER HUMANS OR ANIMALS? IF SO, PLEASE DESCRIBE BRIEF?

No

7.4 HAS ETHICAL CLEARANCE BEEN OBTAINED FROM YOUR INSTITUTION IN CASE OF 7.3?

Attached along with.

8. LIST OF REFERENCES

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PROFORMA

Sr. No

Name : Patient ID :

Age : Sex :

Mode of injury :

Past H/O : h/o CAD , CVA , HTN, DM

Personal H/O : h/o smoking , alcohol

LOCAL EXAMINATION OF ANKLE / HIND FOOT

ANKLE

- Dorsiflexion
- Planterflexion
- Eversion
- inversion

INVESTIGATIONS :

Xrays

Calcaneum-Axial view/Lateral view

- Bohler's Angle
- Gissane Angle

CT calcaneum

PROCEDURE DETAILS

POSTOPERATIVE WOUND STATUS:

DATE OF DISCHARGE:

POST OPERATIVE FOLLOWUP

Signature of Candidate **Signature of Supervisor**

1st visit- 15TH Postoperative day

Suture removal

2nd visit-6th week

Xray-ankle AP/Lateral/Calcaneum axial view

Physiotheraphy

3rd visit-12th week

Physiotheraphy

4th visit-24th week

AOFAS SCORE

Ankle-Hindfoot Scale (100points Total)

PAIN (40 POINTS)	
NONE	40
MILD, OCCASIONAL	30
MODERATE, DALY	20
SEVERE, AL,OST ALWAYS PRESENT	0

Signature of candidate **Signature of Supervisor**

FUNCTION(50 POINTS)	
ACTIVITY LIMITATIONS, SUPPORT REQUIREMENT	
NO LIMITATIONS, NO SUPPORT	10
NO LIMITATIONS OF DAILY ACTIVITIES, LIMITATIONS OF RECREATIONAL ACTIVITIES, NO SUPPORT	7
LIMITED DAILY AND RECREATIONAL ACTIVITIES, CANE	4
SEVERE LIMITATION OF DAILY AND RECREATIONAL ACTIVITY, WALKER, CRUTCHES, WHEEL CHAIR, BRACE	0

MAXIMUM WALKING DISTANCE, BLOCKS	
GREATER THAN 6	5
4-6	4
1-3	2
LESS THAN 1	0

WALKING SURFACES	
NO DIFFICULTY ON ANY SURFACE	5
SOME DIFFICULTY ON UNEVEN TERRAIN, STAIRS, INCLINES, LADDERS	3
SEVERE DIFFICULTY ON UNEVEN TERRAIN, STAIRS, INCLINES, LADDERS	0

Signature of candidate **Signature of Supervisor**

GAIT ABNORMALITY	
NONE, SLIGHT	8
OBVIOUS	4
MARKED	0

SAGGITALMOTION (FLEXION PLUS EXTENSION)	
NORMAL OR MILD RESTRICTION (30 DEGREE OR MORE)	8
MODERATE RESTRICTION(15 -29 DEGREE)	4
SEVERE RESTRICTION (LESS THAN 15)	0

HIND FOOT MOTION (INVERSION PLUS EVERSION)	
NORMAL OR MILD RESTRICTION (75-100 % NORMAL)	6
MODERATE RESTRICTION (25-74 % NORMAL)	3
MARKED RESTRICTION(LESS THAN 25 % NORMAL)	0

Signature of candidate **Signature of Supervisor**

ANKLE HINDFOOT STABILITY(ANTEROPOSTERIOR, VARUS-VALGUS)	
STABLE	8
DEFINITELY UNSTABLE	0

ALIGNMENT(10 POTNTS)	
GOOD, PLANTIGRADE FOOT, ANKLE HINDFOOT WELL ALIGNED	10
FAIR, PLANTIGRADE FOOT, SOME DEGREE OF ANKLE HINDFOOT MALALIGNMENT, OBSERVED, NO SYMPTOMS	5
POOR NON PLANTIGRADE FOOT, SEVERE MALALIGNMENT. SYMPTOMS	0

*EXCELLENT: >90

*GOOD: 75-89

*FAIR: 60-74

*POOR: <60

Signature of candidate

Signature of Supervisor

INFORMED PATIENT CONSENT

Date: _____

I.....D/o, W/o, S/o..... .....am willing to participate in the study **"TO STUDY THE UNION RATES AND COMPLICATIONS ASSOCIATED WITH SURGICALLY MANAGED FRACTURE CALCANEUM"** The procedure with its complications has been explained to me in local vernacular language. I have fully understood that no special tests and extra expenditure in any form, merely for the purpose of thesis is being carried out. I am free to opt out the study any time without assigning any reason.

....

Signature of the Witness Signature of the patient

Name:

Signature of Candidate **Signature of Supervisor**

मरीज अनुमति फार्म

तिथि _____

मैं _____ पत्नी/पुत्र/पुत्री _____

निवासी _____

इस शोधकार्य **"TO STUDY THE UNION RATES AND COMPLICATIONS ASSOCIATED WITH SURGICALLY MANAGED FRACTURE CALCANEUM"** में भाग लेने के लिए सहमत हूँ। मैं इस शोधकार्य में भाग लेने के लिए अपनी स्वेच्छा से तैयार हूँ। मैं पुष्टि करता/करती हूँ की यह स्वीकृति देने के लिए मुझे कोई आर्थिक प्रलोभन नहीं दिया गया और न ही दबाव डाला गया है। मुझे इस शोधकार्य का उद्देश्य स्पष्ट कर दिया गया है और मुझे यह विश्वास है की यह विज्ञान और मानवता के लाभ के लिए है। मुझे इस शोधकार्य में होने वाले जोखिम के बारे में समझा दिया गया है और मेरी समझ में यह जोखिम बहुत मामुली है।

मैं इस शोधकार्य में भाग लेने के सम्बन्ध में किसी भी समय अपनी अस्वीकृति व्यक्त कर सकता/सकती हूँ और मेरे अस्वीकृति व्यक्त करने का मेरे इलाज पर कोई प्रभाव नहीं पड़ेगा।

_____ _____

गवाह के हस्ताक्षर रोगी के हस्ताक्षर/अंगूठे का निशान

नाम: नाम:

_____

अन्वेषक के हस्ताक्षर

_____

विद्यार्थी के हस्ताक्षर

ਮਰੀਜ਼ ਰਜ਼ਾਮੰਦੀ ਫਾਰਮ

ਮਿਤੀ_____

ਮੈ_____ਪਤਨੀ/ਪੁੱਤਰ/ਪੁੱਤਰੀ_____

ਵਾਸੀ _____

"TO STUDY THE UNION RATES AND COMPLICATIONS ASSOCIATED WITH SURGICALLY MANAGED FRACTURE CALCANEUM" ਤੇ ਚਲ ਰਹੀ ਖੋਜ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਰਜ਼ਾਮੰਦ ਹਾਂ। ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਮੈ ਆਪਣੀ ਮਰਜ਼ੀ ਨਾਲ ਤਿਆਰ ਹਾਂ। ਮੈ ਇਹ ਦਸਣਾ ਚਾਹੁੰਦਾ ਹਾਂ/ ਚਾਹੁੰਦੀ ਹਾਂ ਕੇ ਇਹ ਰਜ਼ਾਮੰਦੀ ਦੇਣ ਵਾਸਤੇ ਮੈਨੂ ਕਿਸੇ ਵੀ ਤਰਾਂ ਦਾ ਲੋਭ-ਲਾਲਚ ਨਹੀ ਦਿੱਤਾ ਗਿਆ ਅਤੇ ਨਾ ਹੀ ਕੋਈ ਦਬਾ ਪਾਇਆ ਗਿਆ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਦਾ ਮਨੋਰਥ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ ਅਤੇ ਮੈਨੂ ਇਹ ਭਰੋਸਾ ਦਵਾਇਆ ਗਿਆ ਹੈ ਕੇ ਇਹ ਖੋਜ ਵਿਗਿਆਨ ਅਤੇ ਮਾਨਵਤਾ ਦੀ ਭਲਾਈ ਲਈ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਵਿਚ ਹੋਣ ਵਾਲੇ ਖਤਰੇ ਬਾਰੇ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ ਅਤੇ ਮੈਨੂ ਇਹ ਯਕੀਨ ਹੈ ਕੇ ਇਹ ਖਤਰਾ ਬਹੁਤ ਮਾਮੂਲੀ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਦਾ ਢੰਗ – ਤਰੀਕਾ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ।

ਮੈ ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਬਾਰੇ ਆਪਣੀ ਰਜ਼ਾਮੰਦੀ ਕਿਸੇ ਵੀ ਸਮੇ ਵਾਪਸ ਲੈ ਸਕਦਾ ਹਾਂ/ ਸਕਦੀ ਹਾਂ ਅਤੇ ਮੇਰੀ ਰਜ਼ਾਮੰਦੀ ਵਾਪਸ ਲੈਣ ਦਾ ਮੇਰੇ ਇਲਾਜ ਤੇ ਕੋਈ ਅਸਰ ਨਹੀ ਹੋਵੇਗਾ।

_____

ਗਵਾਹ ਦੇ ਹਸਤਾਖਰ

ਮਿਤੀ_____

ਪਤਾ _____

_____

ਮਰੀਜ਼ ਦੇ ਹਸਤਾਖਰ

ਮਿਤੀ_____

ਪਤਾ _____

_____

ਨਿਰੀਖਕ ਦੇ ਹਸਤਾਖਰ

_____

ਸਿਖਿਆਰਥੀ ਦੇ ਹਸਤਾਖਰ